OAKVILLE CREEK WATER QUALITY STUDY JULY 1973

1974

Ministry of the Environment

The Honourable William G. Newman, Minister

Everett Biggs, Deputy Minister

ONTARIO MINISTRY OF ENVIRONMENT

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WATER RESOURCES BRANCH

1974

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- CONTENTS -

LIST OF APPENDICIES

LIST OF FIGURES

LIST OF TABLES

LIST OF CONTRIBUTORS

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INTRODUCTION

An intensive water quality study of the main branch of Oakville Creek was undertaken primarily to document the impact on water quality of the proposed expansion of the Town of Milton to a population of 28,000 with improved sewage treatment facilities and low flow augmentation from the new Hilton Falls Reservoir and from Kelso Reservoir.

With the co-operation of the Halton Region Conservation Authority, gates at the Kelso Dam were closed in an attempt to create a low flow condition in Oakville Creek downstream from the Town of Milton. Due primarily to leakages at the outlet of the reservoir, the lowest stream flow achieved was an average of 10.9 cubic feet per second measured at Derry Road. At this flow, a water quality survey of the stream was conducted for a 72-hour period from July 16 to July 19. This initial survey was followed by an additional 72-hour study which was carried out between July 24 and July 27. Because of the time consuming nature of the biological work, only some of the sampling was carried out during these two 72-hour periods; the remainder of the samples were collected between late June and early August.

This report is a review of the study and includes a description of the present land and water uses and changes in land and water use which may take place in the Oakville Creek basin. Detailed analyses of the survey results and the developments of water quality models are included.

The information on fisheries was provided by the Ministry of Natural Resources District Office in Cambridge. The District Office conducted a survey of the stream, which coincided with the water quality survey.

SUMMARY

The water-quality study of Oakville Creek, conducted in the summer of 1973, was designed primarily to predict the water-quality effects of the proposed expansion of Milton. The Town of Milton, with an existing population of 9000, has recently expanded the capacity and improved the degree of treatment of its sewage treatment plant to provide for a population of 18,000 people. With the rapid population growth in Milton, the total capacity of this new plant has now been committed to various subdivision proposals and there are plans for further development. The town recently proposed the construction of a larger sewage treatment plant to service a population of 28,000.

Treated municipal and industrial wastes, as well as storm drainage, presently enter Oakville Creek. Due to the rather small size of Oakville Creek in the Milton area, the "waste-assimilative capacity" of the watercourse is quite limited and the Ministry of Environment was concerned about water-quality problems resulting from the proposed expansion. A study was therefore undertaken to define the relationship between urbanization and water quality, so that environmental considerations could be used to govern the extent and type of development, as well as the degree of waste treatment required if Oakville Creek is to continue as a waste receiver.

Upstream from Milton are two reservoirs (Kelso and Hilton Falls) which have been constructed by the Halton Region Conservation Authority. These reservoirs are used to regulate stream flows and with low-flow augmentation, the "waste-assimilative capacity" of the stream can be increased. These control structures were used in the water-quality studies to maintain a low and constant stream flow through the Town of Milton, so that stream quality could be studied on a controlled experimental basis.

Much of the study was carried out during two 72-hour periods in July. A number of physical, chemical, bacteriological and biological parameters were measured, with the main study area being the stretch of creek between the Kelso Reservoir and the confluence of the main and east branches.

The field data clearly revealed that waste materials from the Town of Milton are causing substantial impairment of the downstream waters. While most of the degradation is caused by the sewage treatment plant effluent, there is a definite decrease in water quality even upstream from the plant as a result of problems which normally accompany an urban landscape (e.g. contaminants in storm water). The most noteworthy downstream problem is a lack of dissolved oxygen at night, which results from the respiration of excessive growths of aquatic plants. The nutrient-rich wastes from the sewage treatment plant stimulate massive beds of aquatic plants which cause severe diurnal-nocturnal fluctuations in dissolved oxygen. At highway #25, the dissolved oxygen condition was very unfavourable with a maximum fluctuation between night and day of 15 mg/l, and a minimum night value of 2.7 mg/l. Degradable organic material from the sewage treatment

plant also contributes to the low nocturnal values, although oxygen consumption from this biochemical demand is minor compared with the influence of the aquatic plants. Although the Ministry of Natural Resources has found that a downstream warm water fishery exists in spite of this oxygen situation, it should be noted that the water-quality criteria of the Ministry of Environment for the maintenance of a healthy warm water biota, is a minimum dissolved oxygen value of 5 mg/l.

Further evidence of downstream water-quality degradation is illustrated by the unfavourably-high concentrations of residual chlorine, bacterial levels which make the stream unsuitable for bathing and swimming, a disruption of the bottom macroinvertebrate community, and evidence that the creek in the Milton area is marginal for certain fish species (e.g. common shiners).

With the new, improved sewage treatment plant which will soon contain a phosphorus-removal facility, and with good low-flow augmentation from the reservoirs, it is possible that the population could expand to 18,000 people without further water-quality degradation. While residual chlorine may become a problem with the added volume of treated sewage, this could be corrected by using an alternate sterilant (e.g. ozone) at the sewage treatment plant.

If the Town of Milton expanded to a population of 28,000 people, with conventional methods of handling municipal sewage and storm water, there would be further degradation of Oakville Creek; any further impairment would be unacceptable, since the downstream water quality presently does not meet the criteria of the Ministry of Environment, and decreased water quality would jeopardize existing and legitimate downstream uses. It is therefore apparent that an expansion to 28,000 should be permitted only under one of the following two conditions:

1. Very superior waste-treatment facilities are incorporated. This would probably involve the treatment of storm water, as well as an expensive sophisticated municipal treatment system. This degree of treatment presently does not exist in the province, so that certain technical and developmental problems would be involved.

2. Refrain from using Oakville Creek as a waste receiver. The possibilities of using a land-disposal system, or of piping the wastes to Lake Ontario via a connection with the Oakville municipal collector system, should be investigated.

These alternatives could largely remove water quality as a constraint on the development in the Milton area. However, with expansion of the urban area the affect of urban runoff will become a constraint. In consideration of these alternatives, it should be kept in mind that the Ministry of Environment is not prepared to permit further water-quality degradation in Oakville Creek, and that efforts should be made to upgrade the existing quality.

1. PRESENT LAND AND WATER USE

Land uses in the Oakville Creek drainage basin are of three primary types: urban, agricultural and forested. The part of the watershed upstream from the Niagara Escarpment is primarily forested with some areas of agriculture. Urban development has been limited to the Town of Milton, which presently has a population of approximately 9,000. Downstream from Milton, the land use is primarily low intensity agriculture such as hay production. Some areas are used for free range cattle and sheep feeding.

The primary uses of Oakville Creek are waste assimilation, livestock watering, fishing, swimming and picnicing. It can generally be stated that the stream is made use of aesthetically along its entire length.

In the Town of Milton, waste materials (e.g. urban runoff, industrial and commerical outlets, sewage treatment plant discharge) gain access to the stream and so the creek plays an important role in the transportation and assimilation of wastes. This use, however, is in conflict with other stream uses and may result in limiting the extent of other uses to the point of elimination.

Cattle watering takes place just downstream from Milton. This use requires fair water quality, but can also result in contamination of the stream. In general, however, there is little actively farmed land adjacent to the water-course downstream from Milton.

A limited warm water fishery exists downstream from Milton. This fishery is utilized on a casual basis at a number of the road crossings. A combined warm and cold water fishery is sustained in the creek upstream from the town. The town pond in Milton is stocked with trout which are occasionally caught down-stream from the pond within the town.

The most important recreational area in the watershed is the Kelso Conservation Area operated by the Halton Region Conservation Authority. This park provides numerous outdoor activities such as picnicking, camping, boating, swimming, skiing, tobogganing and fishing. The area is located upstream from Milton at the foot of the Niagara Escarpment.

Downstream from Milton, there are two public day parks and one childrens day camp which border on the creek. The parks are popular picnicking spots. Some limited fishing, wading and swimming by children takes place at these parks.

2. INTERPRETATION OF RESULTS OF INTENSIVE FIELD STUDIES

The detailed results of the intensive field studies are outlined in Appendix I. Analysis of the findings of the intensive field studies have identified the existing water quality status of Oakville Creek and water quality degradation due to the town is apparent.

In terms of water chemistry, the most significant degradation was the nocturnal oxygen depletion downstream from the sewage treatment plant for a distance of 4 to 5 miles. The depletion is primarily due to the respiration of the prolific aquatic plant growth. This same growth produces high dissolved oxygen concentrations at mid day. Superimposed on this oxygen fluctuation is oxygen depletion due to oxidation of carbonaceous and nitrogenous organic matter.

The sewage treatment plant effluent did not greatly alter the BOD_5 concentration of the stream (1.9 mg/l to 3.35 mg/l). The presence of the town itself, excluding the municipal effluent exerted a load of 0.6 mg/l or approximately 33 pounds per day. The total BOD_5 additions would depress DO levels by only one or two parts per million at the extreme. Although the total nitrogen load from the STP is high, more than 60% has been reduced to nitrates by taking up oxygen. The nitrogenous oxygen demand downstream from the STP does not exert itself significantly.

The study indicated that both nitrogen and phosphorus are being readily taken up by the aquatic plants in the process of growth. It is not possible to immediately conclude that a reduction in phosphorus loading to the stream would result in improved oxygen conditions. In order to aid in anticipating the effect of nutrient removal from the sewage treatment plant effluent, a mathematical model was applied to the date obtained during the intensive study. The application of this model is discussed in Appendix II.

Bacterial counts were found to be relatively high. The source of the bacterial contamination appears to be a result of urban and farm activities and not directly attributed to the STP. This is due to the fact that STP effluent was chlorinated to kill off bacteria prior to discharge to the stream. The chlorination itself results in a residual concentration entering the stream. The residual then becomes a damaging factor itself.

The biological work revealed that the benthic macroinvertebrate community, extending from the sewage treatment plant one or two miles downstream, is considerably impaired. This disruption of the benthic community itself does not have drastic implications in terms of stream uses or fisheries production. However, the change from a well balanced, stable community upstream from Milton, to an unbalanced and unstable community downstream, provides further evidence of the environmental impact of the Town of Milton. It is of interest to note that the sampling with the greatest benthic invertebrate impairment was just downstream from the sewage treatment plant effluent, rather than further downstream where the lowest dissolved oxygen readings were found. This would indicate that toxic components of the effluent (e.g. chlorine) may have a greater effect on the

invertebrate population than the dissolved oxygen depletion resulting from the organic and nutrient loadings.

The fish population study indicated that at present, the sewage treatment plant effluent is having a minor or negligible effect on the fishery. However, there are good indications that the urban area itself altered the population and species diversity prior to any influence of the STP, so that any effect of the sewage plant would be masked.

It is also pertinent to note that the fish-caging experiment indicated that the water quality just upstream from the STP is marginal for common shiners and that the effluent aggravates water quality to a point where the caged shiners just downstream all died. It is also of interest to note that the caging studies indicated that water quality just upstream from the sewage treatment plant was less favourable to shiners than the water quality 2 to 3 miles downstream.

The above information clearly reveals that the technical details of water quality impairment below Milton can readily be measured and documented. In order to place this impairment into proper perspective in terms of problems to the downstream users, it is useful to compare the data collected with the quality parameters outlined in "Guidelines and Criteria for Water Quality Management in Ontario", published by the Ministry of the Environment in February, 1973. This booklet describes the quality desired for various types of legitimate stream uses. For example, for watering cattle, the permissible criteria for enterococci of 40 organisms per 100 ml. was exceeded without exception throughout the study area. It is recommended in the booklet that for a warm water fishery a minimum dissolved oxygen concentration of between 4 and 5 mg/l is permissible for short intervals within any twenty-four hour period; at Hwy. #25, dissolved oxygen levels below 4 mg/l occurred daily throughout the study. For water contact recreation, bacterial counts are in excess of the Guidelines, particularly for enterococcus; although swimming is not a major activity, children do make use of the creek for wading and swimming on an informal basis. The "Guidelines" also indicate that abundant plant growth is unacceptable for aesthetic reasons; the extensive growths in Oakville Creek are considered excessive from the point of view of aesthetics.

It is therefore apparent that the desired water quality for legitimate downstream uses is not presently being met. While there is no knowledge of major existing problems with downstream uses, it must be pointed out that the nutrient, organic and bacterial loadings make the stream marginal for a variety of uses. Under these conditions, new industrial or municipal developments with wet wastes could not use the downstream waters for assimilation, there is a minimal "safety margin" for many of the aquatic animals including fish species, and a small accidental waste discharge or unexpected low flows could have pronounced effects on the stream.

3. FUTURE GROWTH CONSIDERATIONS

The present sewage treatment facilities for Milton have the capacity to accommodate a loading equivalent to approximately 18,000 people. Changes in policy planning have developed such that Milton is now limited in expansion in all directions. The proposed "Parkway Belts" as outlined by the Ministry of Treasury, Economics and Intergovernmental Affairs report on Development Planning in Ontario, entitled "The Parkway Belt West" borders Milton to the west at the CNR tracks, to the south at Derry Road and to the east at Oakville Line III. To the north, growth is restricted by Highway 401. To the northwest growth could be limited by the proposed "Niagara Escarpment Planning Area" as outlined by the Ministry of Treasury, Economics and Intergovernmental Affairs in their report entitled "To Save the Escarpment." These limits to growth, however, are not likely to become a constraint for some time. The constraints to growth at this time will be the ability of the stream to assimilate wastes.

3.1 PROPOSED SEWAGE TREATMENT PLANT EXPANSION

The Town of Milton is applying for an extension to their sewage treatment plant so that a population of 28,000 can reside in the town. The present population of approximately 9,000 is generating sewage wastes at approximately 90 gallons per capita per day.

Seven-day flows for Oakville Creek at the gauging station at Derry Road with a 95% probability of exceedance are 6 cubic feet per second between November and May and 4 cubic feet per second between June and October.

It has been estimated from 13 years of flow records that flows in the stream could be augmented from Kelso and Hilton Falls reservoirs to provide flows of 13 cubic feet per second from May through to the end of September. The summer will be critical to water quality due to the aquatic plant growths and higher water temperatures. It should be noted, however, that flows of approximately 13 cfs are likely to occur for several weeks for each summer or fall. Flow augmentation for the winter was found to fail for one of the years on record since summer flow augmentation would use all available storage. Low flow for that year was found to average 7 cfs.

Estimated quality of the effluent from the Milton sewage treatment plant with a population of 28,000 and assuming 80% phosphorus removal, 100 gallons per capita per day water use and the development of only light industry would be:

	Concentration mg/1	Load lb/day
BOD_5	7.5	210
Sol. P.	0.78	22
Total Kjeldahl Nitrogen	4.9	138
Nitrates	9.4	260

if the effluent concentrations of the proposed plant are similar to those of the plant recently installed.

If the upstream water quality at the time of the proposed STP expansion is assumed to be the same as that of the study, which would be a conservative estimate since increased development would result in an increased addition to the stream from urban drains and runoffs, the resulting stream quality, after sewage treatment plant effluent additions, would be 3.6 mg/l BOD_5 or 360 pounds per day, .24 mg/1 soluble phosphorus or 25 pounds per day and 1.6 mg/l nitrates or 156 pounds per day.

3.2 EXPANSION OF URBAN AREA

A need for expanded sewage treatment facilities occurs as a result of pressure for growth in the town. This growth not only manifests itself in terms of greater population, but also in the form of increased area of land put to urban use. This change in land use will result in change in the quality of water which drains from the land. The lands being converted to urban use were previously heavily farmed; now most of this land is either lightly farmed or unused awaiting urbanization. Enrichment of the creek from this land is presently low, with urbanization the quality of the water draining this land will deteriorate. Urban drainage is traditionally rich in biological oxygen demand, nutrients such as phosphorus and nitrogen, and fecal bacteria. The effects of the present urban drainage were apparent from the results of the intensive study, even though relatively dry conditions prevailed. An increase in urban area will result in a proportional increase in the pollutional load to the creek if urban drainage remains untreated.

Milton's urban runoff drains to Oakville Creek. A considerable portion of this drainage enters the creek downstream from the sewage treatment plant through the Ontario Street Creek and the Bronte Street storm drain. The town has plans to alter the storm drainage system considerably so that much of the area, now drained by the Ontario and Bronte street drains would be diverted to the main Oakville Creek, upstream from the sewage treatment plant. The increased urban drainage and alteration of the storm drains system will result in degradation of water quality upstream from the sewage treatment plant.

3.3 STREAM RECHANNELIZATION

The Halton Region Conservation Authority is presently conducting a program of stream rechannelization through the Town of Milton. Although this type of project results in an hydraulically more efficient stream, it also results in some significant changes to the stream.

The actual justification for the rechannelization is not apparent from the consultants report. The project will cost in excess of one million dollars. From a study of the flow figures used to design the new channels, it appears that the expected flood flows are generated in part by the proposed changes in the urban drainage system and the projected increase in urban area. Conversion of land from rural to urban use results in an increase in flood peaks and a decrease in low flows.

The initial construction has resulted in an increase in stream turbidity and silting. The construction phase is illustrated in photographs 1 and 2.

The rechannelization will result in the removal of much of the tree cover, which despite tree planting programs, will result in more sunlight reaching the stream and increase water temperature. This would reduce the dissolved oxygen carrying capacity of the water.

The length of the streambed will be shortened by reducing the number of bends. This, in conjunction with a smoother channel, will result in decreased travel time which will in turn extend the distance contaminants travel prior to assimilation. Photograph 3 illustrates the finished channel.

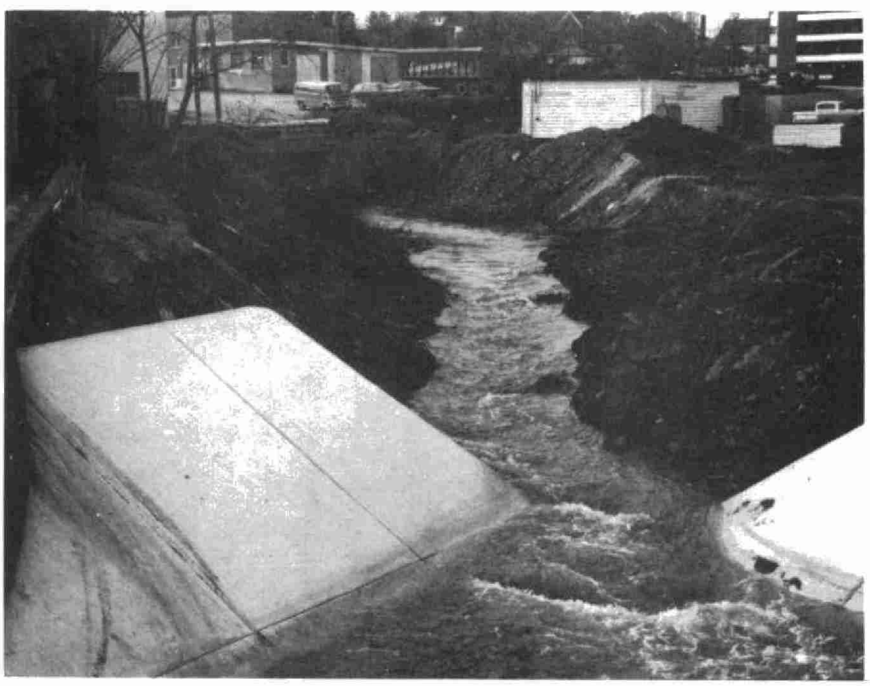
Portions of the rechannelization have already taken place. Much of the streambed has been removed between Main Street and the sewage treatment plant. The work conducted to date has resulted in significant increases in turbidity. Upstream from construction, turbidity was measured at 12 FTU's while immediately downstream from construction turbidity had increased to 82 FTU's. This is a significant increase and is in excess of this Ministry's criteria.

Subdivision developers are also active in stream rechannelization within Milton. Photograph 4 illustrates stream rechannelization in progress at the southern limit of the town. Generally, private groups take even fewer precautions than the contractor for the conservation authority.

(1)

Excavation of stream prior to construction of concrete channel.
Excavated material piled on right bank.

(2)



Stream bed being prepared for concrete lining.

(3)

Concrete lining completed in tributary to West Branch of Oakville.

(4)

Preparations for housing development by private developer. New stream bed is being constructed at right. Existing stream channel is filled in and stream is cutting through fill.

4. CONCLUSIONS

Any expansion of the town could result in three changes which will affect the quality of Oakville Creek.

1. increased urban runoff
2. increased waste load from urban runoff
3. increased sanitary waste load

In anticipating the increase in urban runoff, the Halton Region Conservation Authority has already started reconstruction of the creek channel to handle the expected flood flows. The re-channelization will make the creek unsuitable for most water uses within the town as well as decrease its capacity to assimilate both urban wastes and sewage treatment plant effluent. Urbanization also results in a decrease in low flows which will mean greater reliance on flow augmentation as the urban area increases.

As the urban area expands and urban drainage increases, the waste load carried in the stream drainage system will increase, thus further degrading downstream water quality to the detriment of water users.

The creek has limited capacity to assimilate wastes without adverse results (e.g. dissolved oxygen problems). The capacity can be extended to a degree with low flow augmentation. Once the acceptable "receiving capacity" of the stream is reached, the only way to handle increased sanitary sewage loads is to improve the degree of treatment. With low flow augmentation and the improved sewage treatment recently provided by the town for a population of 18,000 it is likely that the quality of the stream will be similar to that observed during the study. It is essential to maintain low flow augmentation during the summer months if water quality is not to be further degraded. Any further loading such as the expected population increase to 28,000 people will result in decreased quality.

The extent of population expansion is presently limited by the desired level of water quality in Oakville Creek. There are three obvious water quality levels possible; further degradation, present quality or improved quality. Alternatives which will result in further degradation of water quality are not acceptable. Therefore, the sewage treatment plant expansion as proposed by the town would not be satisfactory unless no increase in BOD_5 nutrients and chlorine residual occur above the levels of the existing 1.8 M.G.D plant operating at capacity.

Improvement of water quality will require greater controls on the quantity of STP effluent and the quality of any urban drainage. Population growth in Milton could be compatible with improved water quality if the stream is no longer used for waste assimilation.

5. RECOMMENDATIONS

Since the existing water chemistry and bacteria concentrations are not compatible with many of the identified and legitimate water uses, it is recommended that every effort be made to improve the quality of Oakville Creek.
This implies:

1. Any new sewage treatment plant proposal should at a minimum provide for no increase in effluent loads of BOD_5, nutrients and chlorine residual above those of the existing plant operating at its capacity.

2. Alternative sewage treatment and effluent disposal systems compatible with improved water quality should be investigated in detail. (This could include such approaches as developing a land disposal system for effluent, piping effluent to Lake Ontario or if technically possible upgrading effluent quality to that of the upstream creek quality).

3. Milton's urban drainage system should be investigated in order to identity sources of contaminants to the stream and reduce the contamination as much as possible.

APPENDIX I

APPENDIX I

FINDINGS OF INTENSIVE STUDY

1. CHEMICAL PARAMETERS

In the following presentation, all chemical values discussed refer to arithmetic mean values. Since the dissolved oxygen concentration in water is dependent on the temperature and rate of photosynthesis and respiration in the stream, there is a variation throughout the day. During the study, temperature was relatively constant in the range of 19 to 22°C so that the variation in dissolved oxygen (DO) concentration was primarily due to photosynthesis and respiration. Dissolved oxygen results are presented here in terms of the maximum daily fluctuations and the minimum values observed during the study, in order to illustrate the significance of the aquatic plant growth.

The study findings were based on samples taken at regular intervals throughout the 72 hour studies. Dissolved oxygen concentrations and temperatures were determined in the field and approximately 18 determinations were made for each sampling location. Analysis of samples for chlorine content was conducted both in the field and in the laboratory for approximately 5 samples per station. All other chemical and bacterial parameters were determined at the Ministry of Environment laboratory from samples collected in the field and sent to the labs daily. Approximately 8 samples per station were taken, except for the STP effluent where 12 samples were taken, each one a 6 hour composite of 2 samples.

Oakville Creek upstream from any development of the Town of Milton is of excellent quality with a 5-day biochemical oxygen demand (BOD_5) of 1.3 mg/1, minimum dissolved oxygen concentration of 7 mg/1, maximum daily DO fluctuations of 3.2 mg/1, soluble phosphorus less than .001 mg/1 and nitrates of 0.16 mg/1 (all nitrogen values reported as mg/1 N).

Local inputs of materials in the town such as the municipal pond, the P. L. Robertson Company factory and inflowing drains and tributaries altered water quality so that at Oak Street just upstream from the sewage treatment plant (STP), average levels were BOD_5 1.9 mg/1, soluble phosphorus .005 mg/1, nitrates .2 mg/l and with DO fluctuations of 3.5 mg/l. This represents a daily load added to the creek by the town upstream from the sewage treatment plant of 33 pounds per day BOD_5.

The load in the effluent of the sewage treatment plant was 138 pounds per day BOD_5, 30 pounds per day soluble phosphorus and 71 pounds per day nitrates at a flow of approximately 1.4 cubic feet per second. This addition resulted in water quality at a point approximately one mile downstream from the STP outlet at Derry Road (after partial assimilation) of 2.8 mg/l BOD_5, 0.47 mg/l soluble phosphorus, 1.1 mg/l nitrates and a 10.0 mg/l DO fluctuation. This represents a daily load existing in the stream of 165 pounds BOD_5, 28 pounds soluble phosphorus and 65 pounds nitrates at Derry Road. In this one mile of creek, approximately 70 pounds of BOD_5 were removed. The average stream flow at Derry Road was 11 cfs.

Loading from the Town of Milton continued to depress water quality downstream to the bridge at Highway #25 where the lowest oxygen levels were recorded (2.7 mg/l) and the greatest DO fluctuation (15 mg/l) took place. This was at a distance of approximately 2 miles downstream from the sewage treatment plant. The water quality was also aggravated by the cattle pasturing just upstream from this point as illustrated by a BOD_5 increase between Derry Road and Highway #25 (2.8 to 3.0 mg/1).

Soluble nutrients were further assimilated through the growth of aquatic plants and the stream load at Highway #25 was 24 pounds per day soluble phosphorus and 60 pounds per day nitrates.

Abundant growths of aquatic plants were found at the bridge at Brittania Road where the diurnal DO fluctuation was 9.0 mg/l and the minimum DO was 4.4 mg/l. Concentrations of soluble phosphorus and nitrates continued to decrease downstream as did aquatic plant growths. The oxygen situation improved but did not achieve the quality of the east branch at the time the two branches joined. The minimum DO in the main branch at Baseline Road was 5.1 mg/1 while for the east branch the minimum DO was 6 mg/1. A summary of water quality parameters is listed in Table 1. The location of sampling stations is indicated on Figure 1.

1.1 CHLORINE

While a considerable number of samples from Oakville Creek and from the Milton STP effluent were analysed for residual chlorine, interpretation of these data are severely limited due to analytical problems. However, there are reasons to believe that the data obtained provides an indication of the chlorine levels that existed during the test periods (July 16-20 and July 24-27). Average residual chlorine in the STP effluent was found to be 0.3 mg/1. In the creek waters upstream from the effluent, there appeared to be some chlorine (perhaps 0.01 to 0.02 mg/1). Downstream chlorine values appeared to be 0.03 to 0.04 mg/1.

Information in the literature on chlorine is confusing for a number of reasons. Certain analytical complications are a main reason for the gross discrepancies on toxicity which are provided in the literature. However, the work of Zillich and Brungs provide a vast amount of information on chlorine. Based on this literature it can be assumed that the "safe" level of residual chlorine for the maintenance of a healthy aquatic biota is well below 0.10 mg/l.

A number of weeks prior to the intensive studies a fish kill was reported. Upon investigation by the Ministry of Natural Resources and this Ministry (June 20th, 1973), it was found that the Milton STP had been in the process of converting over to new chlorination equipment and some excess chlorine had escaped to the creek at approximately the time of the fish kill. Although it was too late to document the chlorine concentrations, the chlorine was generally thought to be the cause of the fish kill.

2. BACTERIA

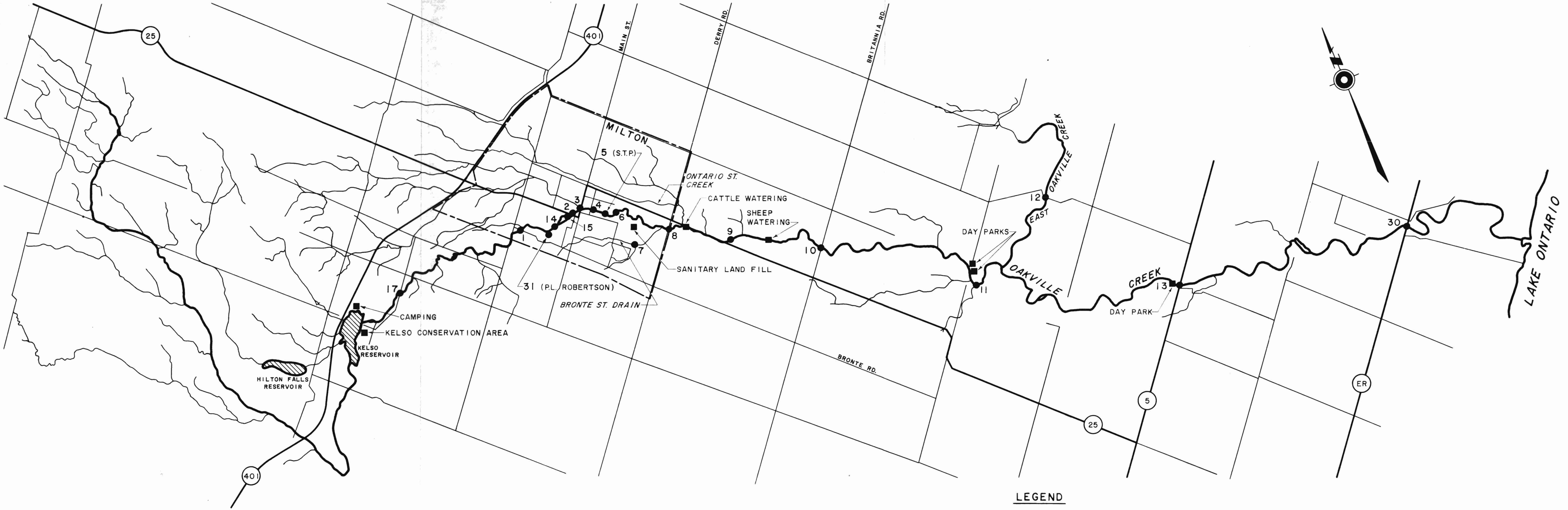
All bacteria counts are given as the number of organisms per 100 ml and are the geometric mean values of all samples for each station.

Bacteria counts upstream from the Town of Milton are greater than that recommended in "Guidelines and Criteria for Water Quality Management in Ontario" for private water supplies (even with treatment), swimming and bathing, and cattle watering. The counts increase through town to high values of total coliforms (3770), fecal coliforms (375) and enterocuccus (450). This increase appears to be due to urban drainage. Due to chlorination, no increase of bacteria resulted from the STP discharge; in fact, there was a slight decrease. The total coliform count rose through the rest of the town with values at Derry Road of total coliforms 8500, fecal coliforms 156 and enterococcus 166.

Contamination from cattle pasturing contributed to increases in fecal coliforms (389) and enterococcus (262) at the crossing of Highway #25 . Bacterial counts then decreased steadily downstream, but did not reach levels recommended by the Ministry of the Environment in the "Guidelines and Criteria for Water Quality Management in Ontario." These criteria recommend levels for cattle watering of less than 40/100 ml enterococcus and for body contact of less than 1000/100 ml total coliforms, 100/100 ml fecal coliforms and 20/100 ml enterococcus.

TABLE I Water Quality Data Summary Oakville Creek

Sampling Station	Oakville Creek Bronte Road	Robertson Co. Effluent	Oakville Creek	Town Pond Effluent	Oakville Creek Martin Street	Tributary Input	Oakville Creek Oak St.	S.T.P. Effluent	Oakville Creek Campbell Drive	Tributary Input	Oakville Creek Derry Road	Oakville Creek Hwy #25	Oakville Creek Britannia Road	Oakville Creek Baseline Road	East Branch Oakville Creek	Oakville Creek Hwy #5	Oakville Creek Q.E.W.	Oakville Creek
STATION NO.	1	31	14	15	2	3	4	5	6	7	8	9	10	11	12	13	30	17
Arithmetic Mean Values in mg/l or ppm																		
Diss. Oxygen																		
Max	10.4	4.6	10.3	13.5	10.1	11.2	10.1	4.9	9.0	11.5	14.4	**18.0**	14.0	16.0	9.1	11.6	11.3	9.2
Min	7.2	3.0	6.7	7.2	6.7	4.0	6.6	3.5	5.1	4.5	4.4	**2.7**	4.9	5.1	6.0	5.6	5.0	7.2
BOD_5	1.3	5.2	1.5	4.1	1.7	2.4	1.9	13.3		4.4	2.8	3.0	2.0	1.8	2.0	1.5	7.3	
Sol. P.	.001	.004	.001	.002	.003	.004	.005	3.9		.15	.47	.38	.32	.23	.006	.079	.046	
Total N	.43	4.6	.69	.49	.64	.56	.63	14.7		.74	1.92	1.61	1.29	.83	.66	.41	.46	
NO_3 as N	.16	1.4	.26	.01	.20	.08	.21	9.4		.12	1.10	.96	.69	.38	.01	.02	.01	
Chlorides	20	52	22	19	22	118	22	200		171	45	43	42	42	17	34	35	
Chlorine Residual					.01			0.14			.027		.01					
Chlorine Combined					.024			0.18			.047		.026					
Total Solids	326	935	352	255	346	550	360	798		667	420	397	395	370	284	312	330	
Susp. Solids	9	11	13	17	13	15	12	13		34	9	6	13	1	12	6	3	
Geometric Mean of Counts per 100 ml																		
Total Coliform	751	663	3230	214	1820	3750	3770	26500	2400	8650	8500	5300	960	790	450	360	240	
Fecal Coliform	287	13	296	10	160	375	380	450	76	244	156	389	46	26	71	39	16	
Enterococcus	389	35	533	33	340	490	450	1070	206	490	166	262	154	133	250	153	63	
Turbidity JTU	4.6	19	4.7	6.3	4.9	4.4	9.7	6.3		18	4.4	3.9	3.9	2.7	6.1		2.8	



LEGEND

- ● — WATER QUALITY MONITORING STATIONS
- ■ — STREAM USES
- ——-——- — TOWN OF MILTON

1 .5 0 1 2 3 4 KILOMETRES

1 1/2 0 1 2 3 MILES

ENVIRONMENT ONTARIO	
OAKVILLE CREEK WATER QUALITY STUDY 1973 FIGURE 1 - MONITORING STATIONS AND WATER USES	
SCALE: AS NOTED	
DRAWN BY: A.R.S.	DATE: DEC., 1973
CHECKED BY:	DRAWING Nº: 73-71-BL

3. BIOLOGICAL STUDIES

3.1 Bottom Fauna

3.1.1 Method

The bottom invertebrate population was evaluated at a total of 22 locations on Oakville Creek during June and July 1973. Figure 2 illustrates that 21 of these sampling stations were located on the main branch, with one location (B-22) near the mouth of the east branch.

Two methods were used to sample the bottom fauna. At 21 of the 22 locations, the "qualitative" sampling method was used; two or three people would spend an equivalent of one man-hour sampling a wide variety of invertebrate habitats. Simple hand sieves and forceps were used to collect organisms from a riffle environment as well as a "pool" or "backwash" type of environment. Rock, submerged twigs, aquatic plant material, sand and mud sediment, etc., would all be investigated for macroinvertebrate life. In this "qualitative" method, emphasis was placed on obtaining a large number of taxa within the timed sampling interval. Therefore, if numerous stones for example supported dense mats of blackflies, only some of these blackflies would be collected, and the collector would then go on to sample another type of habitat. For this reason, the community composition at any one location, as well as the population density, provides only a very rough estimate of the real community composition and density. However, while this method has several substantial disadvantages, it does have the large advantage of obtaining many different taxa from a wide variety of habitats so that the diversity and stability of the invertebrate community can be evaluated.

The second sampling method was the use of "artificial substrates". These substrates were wire mesh baskets (15 cm x 20 cm x 20 cm), with the general appearance of a bicycle carrier basket, filled with 6 cm crushed limestone. The substrates were placed in the stream at 14 of the 22 locations in the latter part of May, and were removed approximately one month later to evaluate the invertebrate community that had become established on the rocks within the substrate. Only one artifical substrate per station was used and in most cases, the sampler was submerged in a riffle area of the stream so that the artificial substrate would not become imbedded in the stream bottom. Also, the riffles provided for a fairly uniform habitat.

Probably the greatest single disadvantage of using artificial substrates is that the invertebrate community which becomes established has only a very crude relationship to the natural community in that particular stream area. The one big advantage of artificial substrates is that the physical habitat becomes uniform and this eliminates the problem of comparing communities between stations which have different physical characteristics.

All organisms collected by both methods were preserved in ethyl alcohol and returned to the laboratory for enumeration and identification. The samples are presently in the permanent invertebrate collection of the Ministry of Environment.


MILTON
S.T.P.
MAIN ST.
DERRY RD.
BRITANNIA RD.
BRONTE RD.
OAKVILLE CREEK
EAST OAKVILLE CREEK
LAKE ONTARIO
KELSO RESERVOIR
HILTON FALLS RESERVOIR
25
401
5
ER
B1
B2
B5
B6
B7
B8
B9
B10
B11
B12
B13
B14
B15
B17
B18
B19
B21
B22
B23
B26
B27
1 .5 0 1 2 3 4 KILOMETRES
1 1/2 0 1 2 3 MILES
LEGEND
0 — MAYFLY
1 — CADDISFLY
2 — STONEFLY
3 — DIPTERIA
4 — WORMS
5 — SNAILS, CLAMS
6 — CRAYFISH, AMPHIPOD
7 — DAMSELFLY, DRAGONFLY, HELLGRAMMITE, ALDERFLY
8 — WATER BUG, WATER BEETLE, MITE
9 — ISOPOD, LEECH, FLATWORM
NOTE
THE "PIE" CHARTS ILLUSTRATE THE NUMERICAL COMPOSITION OF THE INVERTEBRATE COMMUNITIES.
ENVIRONMENT ONTARIO
OAKVILLE CREEK
WATER QUALITY STUDY 1973
FIGURE 2 - "QUALITATIVE"
SAMPLING LOCATIONS AND INFORMATION
SCALE: AS NOTED
DRAWN BY: A.R.S.
DATE: DEC., 1973
CHECKED BY:
DRAWING Nº: 73-71-BL

MILTON
S.T.P.
MAIN ST.
DERRY RD.
BRITANNIA RD.
BRONTE RD.
B1
B6
B7
B8
B11
B12
B15
B16
B17
B18
B21
B22
B23
B27
KELSO RESERVOIR
HILTON FALLS RESERVOIR
EAST OAKVILLE CREEK
OAKVILLE CREEK
LAKE ONTARIO
25
401
5
ER
.5 0 1 2 3 4 KILOMETRES
1 1/2 0 1 2 3 MILES
LEGEND
0 — MAYFLY
1 — CADDISFLY
2 — STONEFLY
3 — DIPTERIA
4 — WORMS
5 — SNAILS, CLAMS
6 — CRAYFISH, AMPHIPOD
7 — DAMSELFLY, DRAGONFLY, HELLGRAMMITE, ALDERFLY
8 — WATER BUG, WATER BEETLE, MITE
9 — ISOPOD, LEECH, FLATWORM
NOTE
THE "PIE" CHARTS ILLUSTRATE THE NUMERICAL COMPOSITION OF THE INVERTEBRATE COMMUNITIES.
ENVIRONMENT ONTARIO
OAKVILLE CREEK
WATER QUALITY STUDY 1973
FIGURE 3 – "ARTIFICIAL SUBSTRATE" SAMPLING LOCATIONS AND INFORMATION
SCALE: AS NOTED
DRAWN BY: A.R.S.
DATE: DEC., 1973
CHECKED BY:
DRAWING Nº: 73-71-BL

3.1.2 Results

-Community Balance-

Figures 2 and 3 illustrate that Oakville Creek in general supported a fairly large variety of invertebrate taxa with a good balance between the major groups of organisms; this is indicative of a healthy aquatic environment. Invertebrate groups that are both common and fairly abundant at most of the sampling locations included mayfly nymphs, caddisfly larvae, diptera larvae (primarily midges and blackflies), and crustaceans.

In terms of a more detailed description of the bottom fauna community along the various parts of the creek, the study area can be divided into three sections.

(1) the section from the headwaters down to and including Station B-16
(2) Stations B-17, B-18, B-19 and perhaps B-21, which are located just downstream from Milton sewage treatment plant and
(3) the lower reaches of the study area extending from Station B-21 or B-22 downstream (including Station B-26 on the east branch).

The upper section (No. 1) supports a very stable community with good balance and with the "pollution sensitive" taxa constituting a major part of the overall community. This is the only stream section where stonefly nymphs, which require a pollution-free and cool environment, are common; surprisingly, only one family of stonefly nymphs, namely Perlidae, was found. Mayflies, which are also relatively pollution sensitive, are one of the most common and abundant invertebrate orders in this section of Oakville Creek. A total of six families of mayflies were found, with four or five families frequently recovered from a single sample (qualitative sample or artificial substrate); this diversity again illustrates the high quality of water in this section of the watercourse. Not unlike mayflies, caddisflies were common and fairly abundant with a total of seven families being found in this section, and as many as five families per sample. A variety of crustaceans, molluscs, dragonflies, damselflies, alderflies waterbugs, leeches and mites were also found in this upper section. The two main types of diptera larvae in this upper section of the creek were midges (i.e. Chironomidae) and blackflies (i.e. Simuliidae); information from the qualitative samples revealed that while diptera larvae were commonly found, they constituted a small part of the overall invertebrate population. The substrates, however, seemed to provide an attractive artificial environment for midges and blackflies and Figure 3 therefore illustrates a dominant role of these organisms within the substrate community. Oligochaete worms, which typically dominate the community in an organically enriched area, are not common or abundant in the upper reaches of Oakville Creek and in fact were found in only 5 of the 22 samples collected.

Figures 2 and 3 illustrate that the invertebrate community balance in the Milton area (section 2) was somewhat disrupted. Stoneflies were not found, the numerical significance of mayflies and caddisflies within the community was considerably reduced, and worms and midges constituted a dominant part of the community; this change in community structure was particularly evident

at Stations B-17 and B-18, located just downstream from the sewage treatment plant effluent. It is also pertinent to note that within the mayfly order, a total of only three families were found in the seven samples collected. Also, only one family of caddisflies was found, namely Hydropsychidae, unlike the situation upstream where as many as 5 families were found in a sample. The diptera population in this section of the creek was comprised of large numbers of midge and blackfly larvae; the invertebrate population on the artificial substrates at B17 and B18 was greater than 90% diptera larvae. Information from the qualitative samples revealed that worms as well as dipterans were numerous in this Milton section; e.g. approximately one-half of the organisms collected at B18 were oligochaete worms.

The balance of invertebrate groups in the lower section of Oakville Creek, (section 3) including information from East Oakville Creek, is considerably better than that found in the Milton area (section 2), and only slightly poorer than that found in the upper reaches (section 1). The main pertinent differences between section 1 and 3 are that section 3 has a greater dominance of diptera larvae (both midges and blackflies are abundant), stoneflies were found in only a few samples and in low numbers, and the maximum number of families of mayflies and caddisflies in section 3 was 5 and 3 respectively, compared with 6 families of mayflies and 7 families of caddisflies upstream.

-Worms and Midges-

Figure 4 illustrates the ratios of worms (i.e Oligochaetes) and midges (i.e. Chironomidae) to the total numbers of organisms; data from only the qualitative samples is used, since the artificial substrates appeared to have a high attraction for midges and had only a poor relationship to the natural stream population. Organic enrichment of a stream normally results in increased populations of worms and midges and the height of the bars in Figure 4 can therefore be used to indicate the degree of stream enrichment. The figure illustrates that upstream from Milton, the ratio is low. Downstream, the ratio is considerably larger with the highest ratio (93.9%) being just downstream from the sewage treatment plant effluent. Not unlike the previous description of community structures at the various sampling locations, Figure 4 indicates three types of water quality in the study area, with the best water quality in section 1 (headwater area), and the poorest water quality in section 2 (Milton area); the quality of section 3 (downstream area) would appear to be intermediate.

-Diversity-

Clean water environments are characterized by a "diverse" community in which there is a large variety of taxa and a fairly low population density. The high diversity is biologically very desirable since it provides for a stable ecological system. Figure 5 illustrates the total numbers of taxa (i.e. families) found at each sampling location. The figure illustrates that there is considerable variability between stations with no stretch of the creek having unusually high or unusually low numbers of taxa. However, it appears that the Milton area

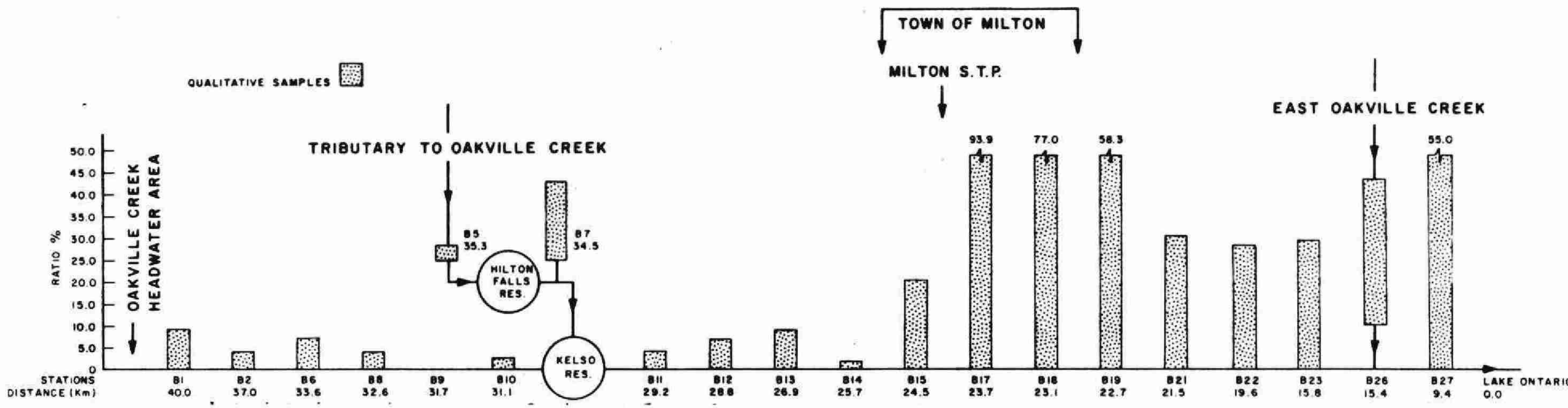


Figure 4: The Ratio (%) of Worms (i.e. Oligochaete) and Midges (i.e. Chironomidae) to the Total Number of Organisms at the Various Sampling Locations

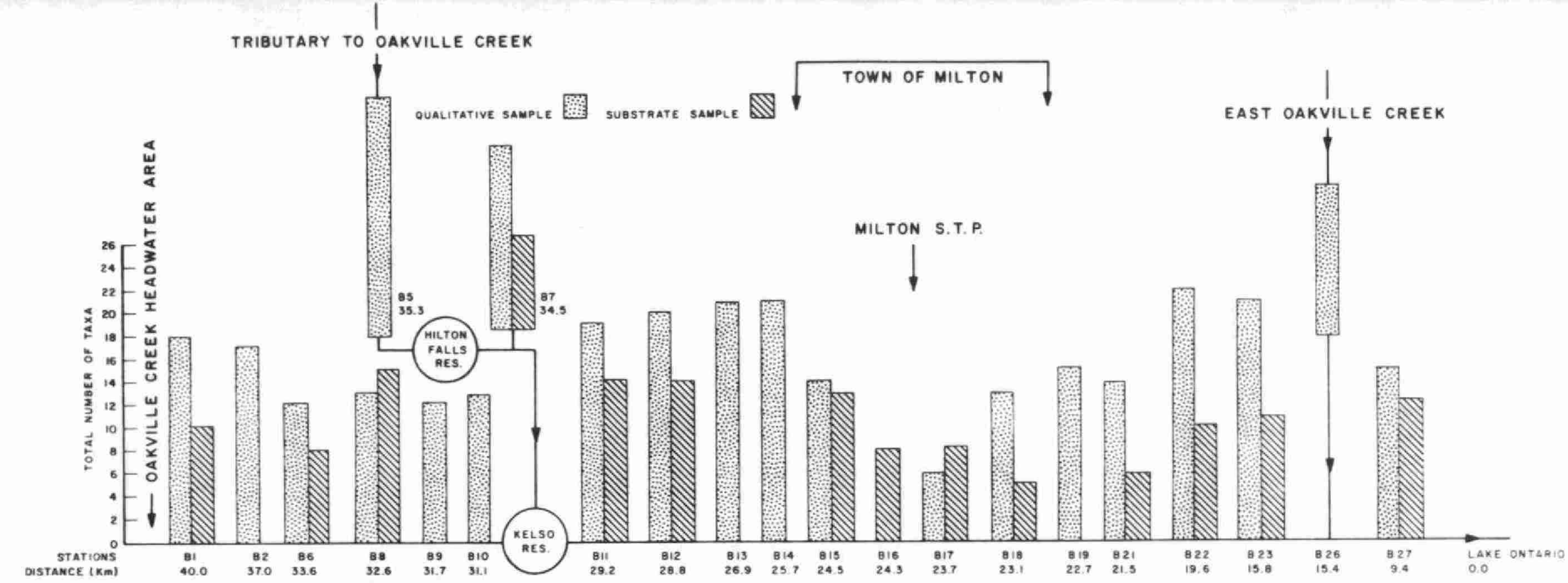


Figure 5: Total Number of Taxa (i.e. Families) found at each of the Sampling Locations

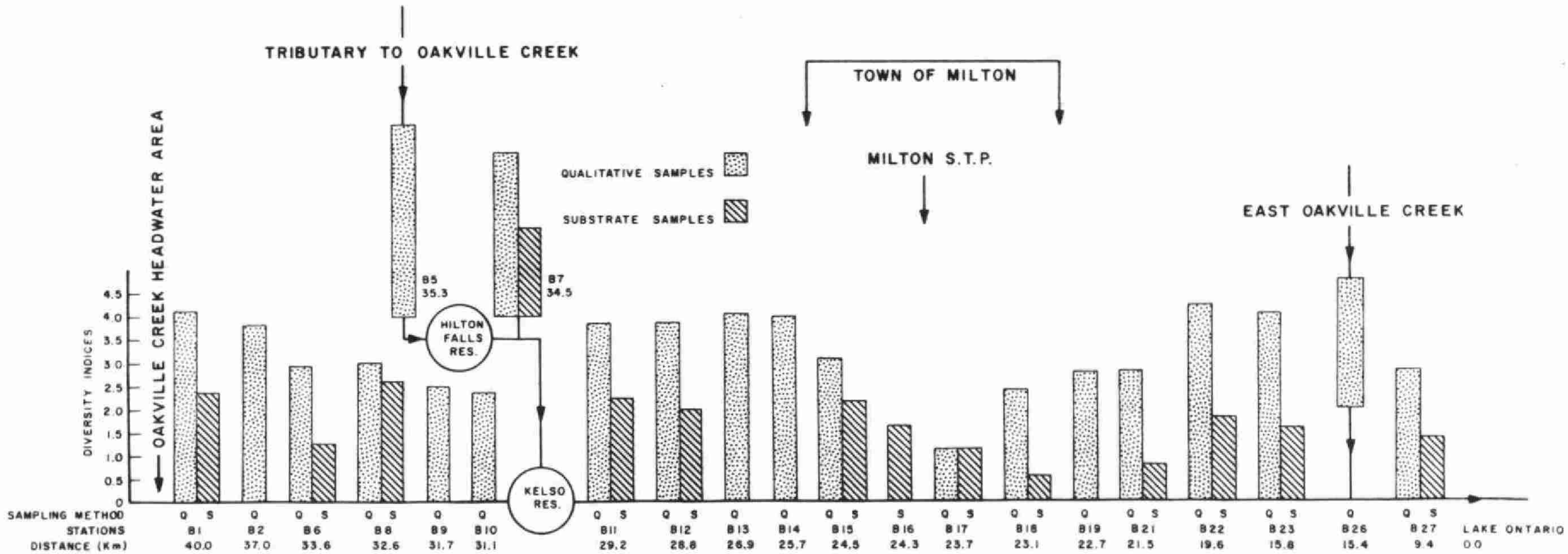


Figure 6: Diversity Index at each of the Sampling Locations

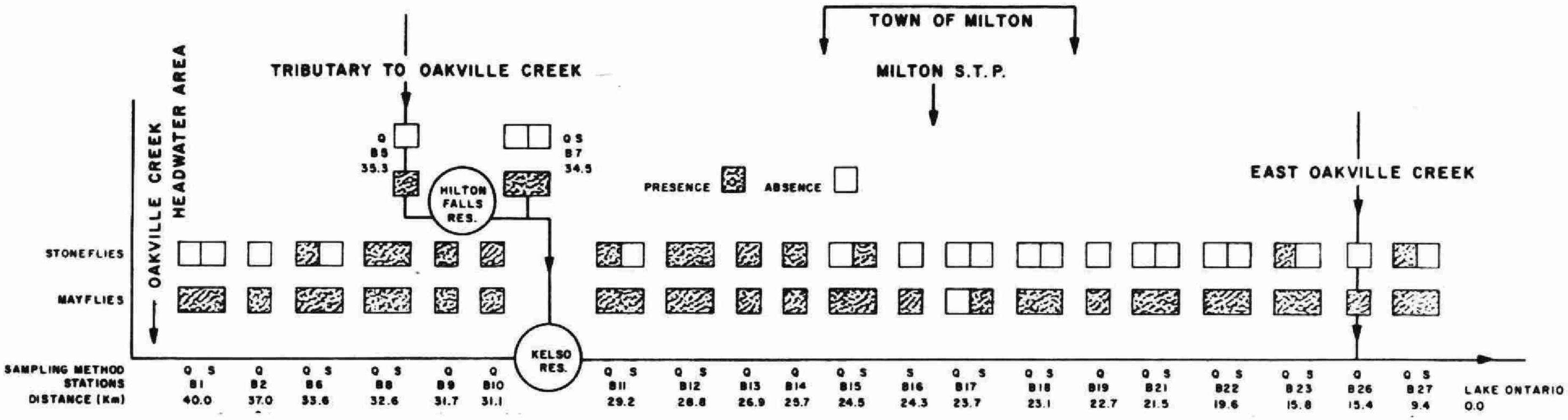


Figure 7: Presence and Absence of Stoneflies and Mayflies at Each Sampling Location

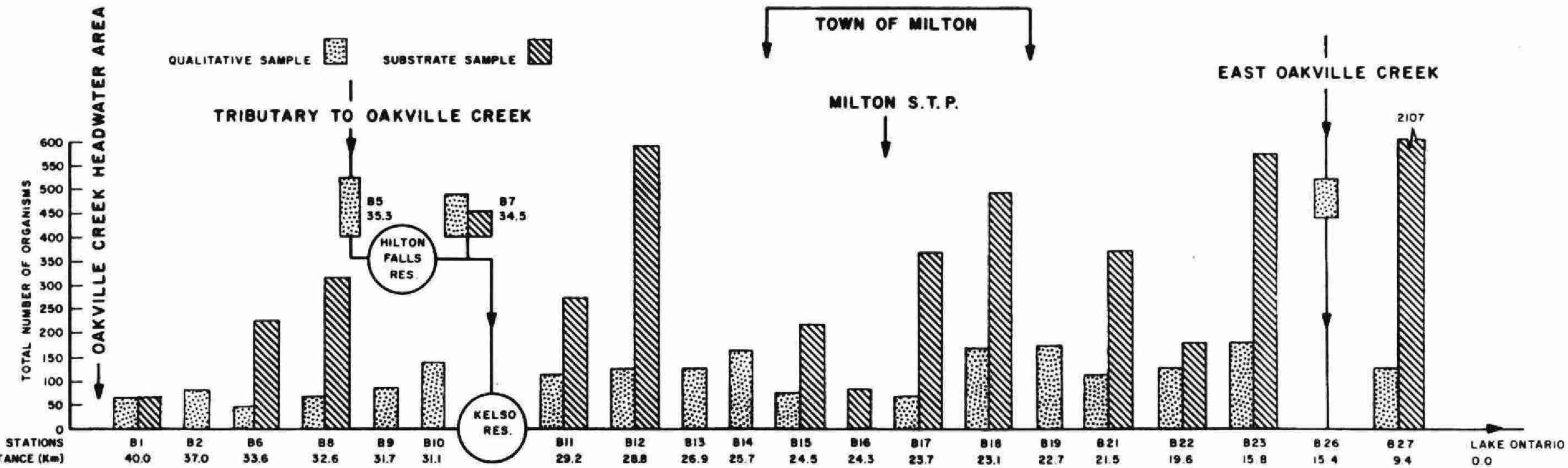


Figure 8: Total Numbers of Organisms Found at Each of the Sampling Stations

(B-16 to B-21) has a slightly smaller variety of taxa than the upstream and downstream sections. Community diversity can also be expressed numerically. Figure 6 illustrates a numerical index that Margalef has developed, namely $D=\frac{s-1}{\log_e N}$, where s = number of taxa (families in this case) and N = number of organisms. Not unlike Figure 5, Figure 6 illustrates that while there is considerable variability between sampling locations, the diversity indicies are fairly similar throughout the study area. However, it appears that there may be a slight decrease in diversity in the Milton area, particularly just downstream from the municipal sewage effluent (B-17) where the indices are low for both the qualtative sample and the artificial substrate.

-Presence-Absence-

The presence and absence of water quality "indicator" organisms is frequently useful in stream evaluations. The stonefly and mayfly orders are commonly used since both groups are restricted to fairly "clean water" environments. Figure 7 illustrates that mayflies were found in every sample with the exception of the qualitative sample collected just below the sewage treatment plant (B-17). Stoneflies, which in general are more "pollution sensitive" than mayflies, were found in most samples collected upstream from Milton; however, from station B-16 and downstream, stoneflies were found in only two of the fifteen samples collected. It appears that the stretch of stream extending from Milton (B-16) downstream to Station B-22 is unsuitable for stonefly nymphs.

-Density-

Figure 8 illustrates the total numbers of invertebrates found in each of the samples that were obtained. There is of course a large natural variability between samples due to a large number of reasons (e.g. differing habitats, differences in predation rates by fish). However, the data does indicate that there are no gross changes in invertebrate densities caused by the Town of Milton. This is unlike some streams where worm and midge densities reach very large populations, as a result of very heavy organic loadings.

TABLE 2 NUMBERS OF ORGANISMS/SAMPLE

QUALITATIVE SAMPLE - Q
SUBSTRATE SAMPLE - S

	B1		B2	B5	B6		B7	B8		B9		B 10
	Q	S	Q	Q	Q	S	Q	S	Q	S	Q	Q
MAYFLY												
Heptageniidae	3	2	10	12	-	-	-	3	10	34	22	6
Leptophlebiidae	-	19	1	-	1	-	-	5	7	8	7	16
Baetidae	3	5	7	6	15	107	-	-	3	126	2	-
Caenidae	-	-	14	5	1	2	2	-	-	72	-	-
Ephemeridae	-	-	2	-	-	-	-	-	-	3	-	11
CADDISFLY												
Hydropsychidae	-	2	11	9	12	-	-	11	11	14	9	23
Limnephilidae	8	-	-	3	-	-	-	-	2	4	3	2
Leptoceridae	-	-	-	1	-	-	-	-	-	7	-	-
Philopotamidae	-	-	-	5	8	-	-	-	3	-	6	36
Rhyacophilidae	-	-	-	-	-	-	-	-	1	-	11	15
Psychomyiidae	-	-	-	-	-	-	-	-	-	2	1	1
STONEFLY												
Perlidae	-	-	-	12	-	-	-	-	12	18	12	26
Perlodidae	-	-	-	-	1	-	-	-	-	-	-	-

DAMSELFLY												
Agriidae	1	-	8	-	-	-	-	-	-	-	-	-
Lestidae	-	-	-	-	-	-	1	-	-	-	-	-
Coenagriidae	-	-	-	-	-	-	7	-	-	-	-	-
DRAGONFLY												
Libellulidae	1	-	-	4	-	-	-	-	-	-	-	-
Aeshnidae	1	-	1	-	-	-	-	-	-	-	-	-
HELLGRAMMITE												
Corydalidae	-	-	-	-	-	-	1	-	-	1	2	2
DIPTERA												
Chironomidae	-	31	2	1	3	94	6	21	2	33	-	1
Simuliidae	-	-	-	-	-	-	8	2	-	-	-	-
Tabanidae	1	-	1	-	-	-	-	-	-	-	-	-
Stratiomyiidae	1	-	-	2	-	-	-	-	-	-	-	-
Ceratopogonidae	-	-	-	-	-	-	1	-	-	-	-	-
Unidentified	1	-	-	-	-	-	-	-	-	-	-	-
OLIGOCHAETE												
Tubificidae	2	-	-	-	-	13	-	-	-	-	-	-
WATER BEETLE												
Hydrophilidae	1	-	-	-	-	1	-	-	-	-	-	-
Dytiscidae	1	-	-	1	-	-	7	-	-	-	-	-
Haliplidae	-	-	1	6	-	1	7	-	-	-	-	-
Elmidae	-	-	-	-	1	3	-	-	1	3	-	1

AMPHIPOD												
Talitridae	20	3	5	25	-	-	5	2	3	-	-	-
Gammaridae	1	2	2	-	-	-	-	-	-	-	-	-
WATER BUG												
Corixidae	8	-	-	2	-	-	4	-	-	-	-	-
Gerridae	-	-	2	-	-	-	-	-	-	-	-	-
Veliidae	-	-	1	-	-	1	-	-	-	-	-	-
Belostomatidae	-	-	-	3	-	-	-	-	-	-	-	-
CLAM												
Sphaeriidae	3	-	2	-	-	-	1	2	2	-	1	1
Unionidae	-	-	-	-	1	-	-	-	-	-	-	-
SNAIL												
Planorbidae	2	-	-	5	1	-	21	4	-	1	-	-
Lymnaeidae	5	-	-	1	-	-	1	-	-	-	-	-
Physidae	-	-	1	-	-	-	-	-	-	-	-	-
LEECH												
Glossophonidae	-	-	-	2	1	-	2	-	-	-	-	-
MITE												
Acari	-	1	-	-	-	-	-	-	-	-	-	-

ISOPOD												
Asellidae	-	1	-	-	-	-	-	-	-	-	-	-
CRAYFISH												
Astacidae	-	1	5	1	2	-	3	-	1	3	2	-
TOTAL NUMBER OF ORGANISMS per STATION	63	63	74	114	47	222	77	50	58	329	78	141
TOTAL NUMBER OF TAXA (families) per STATION	18	10	17	19	12	8	16	8	13	15	12	13

	B11		B12		B13	B14	B15		B16	B17		B18	
	Q	S	Q	S	Q	Q	Q	S	S	Q	S	Q	S
MAYFLY													
Heptageniidae	4	8	24	25	37	30	18	7	3	-	1	1	-
Leptophlebiidae	1	1	5	-	14	4	-	-	-	-	-	-	-
Baetidae	16	1	17	15	-	-	1	2	-	-	-	-	-
Caenidae	-	213	-	23	1	6	9	15	-	-	3	7	1
Ephemeridae	11	-	3	-	10	10	-	-	-	-	-	-	-
CADDISFLY													
Hydropsychidae	28	17	22	46	28	27	2	137	62	2	1	-	-
Limnephilidae	3	-	8	-	-	-	-	-	-	-	-	-	-
Leptoceridae	4	5	-	2	-	2	-	-	-	-	-	-	-
Philopotomidae	-	-	-	-	-	1	-	-	-	-	-	-	-
Rhyacophilidae	5	-	1	-	-	-	-	-	-	-	-	-	-
Psychomyiidae	-	-	1	-	2	-	-	-	-	-	-	-	-
Hydroptilidae	-	-	-	1	-	-	-	4	-	-	-		-
STONEFLY													
Perlidae	2	-	7	20	1	4	-	5	-	-	-	-	-
DAMSELFLY													
Agriidae	-	-	-	-	-	-		-	-	-	-	5	-
Coenagriidae	1	-	-	-	1	7	8	-	-	-	-	14	-

HELLGRAMMITE													
Corydalidae	-	-	-	-	-	-	1	-	-	-	-	-	-
DIPTERA													
Chironomidae	1	3	2	231	1	3	5	1	3	55	298	1	328
Simuliidae	4	-	4	189	-	-	-	-	2	3	62	45	163
Tabanidae	-	-	-	-	-	1	-	-	-	-	-	-	-
Tipulidae	-	-	2	-	2	-	-	-	-	-	-	-	-
OLIGOCHAETE													
Tubificidae	-	-	-	18	1	-	11	-	-	4	-	78	-
Lumbriculidae	-	-	-	-	1	-	-	-	-	-	-	-	-
WATER BEETLE													
Hydrophilidae	1	-	1	-	-	-	-	-	-	-	-	-	2
Dytiscidae	3	-	-	-	2	-	-	-	-	-	-	2	-
Haliplidae	-	-	-	-	1	5	-	-	-	-	-	1	-
Elmidae	-	1	1	1	1	-	1	3	12	-	3	1	3
Chrysomelidae	-	-	-	-	-	-	-	-	-	-	-	1	-
AMPHIPOD													
Talitridae	4	1	13	1	1	7	7	-	-	-	-	-	-
WATER BUG													
Corixidae	-	-	1	-	3	13	-	-	-	-	-	-	-
Gerridae	-	-	-	-	-	-	-	-	-	-	-	1	-
Veliidae	-	-	-	-	-	1	-	-	-	-	-	-	-
Mesoveliidae	-	-	-	-	-	-	-	-	-	-	1	-	-
Unidentified	-	-	-	-	-	-	-	1	-	-	-	-	-

CLAM													
Sphaeriidae	-	1	6	-	5	22	3	1	-	-	-	-	-
Unionidae	-	-	-	-	-	1	1	-	-	-	-	-	-
SNAIL													
Planorbidae	3 -	-	-	-	4	6	-	15	-	-	-	-	-
Lymnaeidae	1	1	-	-	-	1	-	-	-	-	-	-	-
Physidae	10	3	1	-	5	5	-	6	1	1	-	-	-
LEECH													
Erpobdellidae	-	-	-	-	-	-	1	-	-	-	-	-	-
MITE													
Acari	-	2	-	20	-	-	-	-	1	-	-	-	-
FLATWORM													
Planaria	-	4	2	3	-	-	-	-	-	-	-	-	-
ALDERFLY													
Sialidae	-	-	-	-	-	-	-	-	-	-	1	-	-
CRAYFISH													
Astacidae	8	5	1	-	4	1	2	2	3	1	-	4	-

TOTAL NUMBER OF ORGANISMS per STATION	111	265	131	595	125	157	70	211	87	66	370	167	497
TOTAL NUMBER OF TAXA (families) per STATION	19	14	20	14	21	21	14	13	8	6	8	13	5

	B19	B21		B22		B23		B26	B27	
	Q	Q	S	Q	S	Q	S	Q	Q	S
MAYFLY										
Heptageniidae	2	4	-	5	7	18	1	7	28	47
Leptophlebiidae	-	-	-	-	-	-	18	-	1	-
Baetidae	-	16	20	10	27	9	51	-	3	140
Caenidae	4	1	5	1	1	2	-	-	16	14
Ephemeridae	-	-	-	-	-	1	-	1	-	-
CADDISFLY										
Hydropsychidae	1	8	93	7	55	-	303	8	2	1125
Leptoceridae	-	-	-	-	-	3		4	7	
Philopotamidae	-	-	-	-	-	-		-	-	39
Unidentified	-	-	-	-	-	-	6	-	-	
STONEFLY										
Perlidae	-	-	-	-		1	-	-	1	-
DAMSELFLY										
Agriidae	27	-	-	3	-	6	-	-	-	-
Coenagriidae	4	11	-	17	-	12	-	14	1	-
DRAGONFLY	-	-	-	-	-	-	-	-	-	-
Aeshnidae	1	-	-	1	-	-	-	-	-	-

HELLGRAMMITE										
Corydalidae	-	-	-	-	-	1	1	-	-	-
DIPTERA										
Chironomidae	12	11	191	9	47	22	155	16	22	192
Simuliidae	17	17	47	5	-	10	36	9	56	533
Tipulidae	-	-	-	-	-	-	-	-	-	2
Rhagionidae	-	-	-	-	-	-	-	-	-	8
Unidentified	1	-	-	-	-	-	-	-	-	-
OLIGOCHATE										
Tubificidae	71	3	-	18	-	5	-	-	-	-
Lumbriculidae	-	4	-	3	-	-	-	-	1	-
WATER BEETLE										
Hydrophilidae	-	-	-	-	-	2	-	-	-	-
Dytiscidae	2	3	-	4	-	3	-	-	1	-
Haliplidae	3	-	-	4	-	-	-	-	-	-
Elmidae	-	-	-	1	1	2	17	1	1	11
Psephenidae	1	-	-	-	-	1	-	-	-	-
AMPHIPOD										
Talitridae	-	5	-	9	-	15	-	1	-	-
WATER BUG										
Gerridae	-	-	-	-	-	-	-	-	-	-
Mesoveliidae	-	-	-	-	-	-	-	-	1	-
Notonectidae	-	-	-	1	-	-	-	1	-	-

CLAM										
Sphaeriidae	-	-	-	12	-	8	-	4	-	-
SNAIL										
Planorbidae	-	2	-	1	-	-	1	5	-	-
Physidae	-	1	-	1	1	4	-	-	-	-
LEECH										
Erpobdellidae	3	-	-	4	-	-	-	-	-	1
MITE										
Acari	-	-	-	-	-	1	-	-	1	-
FLATWORM										
Planaria	-	-	-	1	2	-	-	-	-	-
ALDERFLY										
Sialidae	-	-	-	-	1	-	-	-	-	-
CRAYFISH										
Astacidae	24	23	6	10	20	2	1	2	-	1

TOTAL NUMBER OF ORGANISMS per STATION	173	109	362	127	162	127	584	73	142	2107
TOTAL NUMBER OF TAXA (families) per STATION	15	14	6	22	10	21	11	13	15	12

3.2 Caging Experiments

3.2.1 Introduction

The major part of the biological investigation was an investigation of benthic invertebrate communities which is outlined in the preceding section. As a supplement to this work, several types of aquatic animals were placed in cages in the stream upstream and downstream from the sewage treatment plant. The purpose of these caging experiments was simply to determine whether or not water quality below the sewage treatment plant effluent was poor enough to reduce the short-term survival of selected types of stream biota.

Caged organisms included crayfish (unidentified), caddisfly larvae (Hydropsychidae), mayfly nymphs (Heptageniidae) and minnows (common shiners - Notropis cornutus). Experiments were carried out at a total of five stream locations (EXP-1 to EXP-6 - see Figure 9). Station EXP-1 was located immediately upstream from the sewage plant effluent and was therefore called the "control" station. Station EXP-3 was located approximately 75 meters downstream from the effluent, and the other three stations were further downstream.

All cages were identical. They were empty artificial substrate cages, which have previously been described, with a lining of fibre glass window screening with a sufficiently small mesh to retain the invertebrates.

3.2.2 Crayfish

A number of moderate sized crayfish were collected from the creek immediately upstream from the sewage treatment plant and five specimens were placed in each of five cages on July 16. No mortality occurred in any of the cages over a 5-day period (July 16 to 20). Information from this experiment was complimentary to the data from the qualitative and artifical substrate samples which showed that crayfish were common both upstream and downstream from the sewage treatment plant effluent.

3.2.3 Caddisflies

Hydropsychidae larvae were collected from the EXP-6 station and were placed in the five cages on the afternoon of July 17. Considerable difficulty was experienced in transferring these organisms to the cages without injuring them and as a result, the numbers per cage varied from 1 to 17. The experiment ended on July 19 and Figure 9 illustrates the survival after two days. It is assumed that handling injuries was the cause of death in the four cages where survival was not complete. This caging information again reinforces the qualitative and substrate data which showed that Hydropsychidae larvae were present in the Milton area.

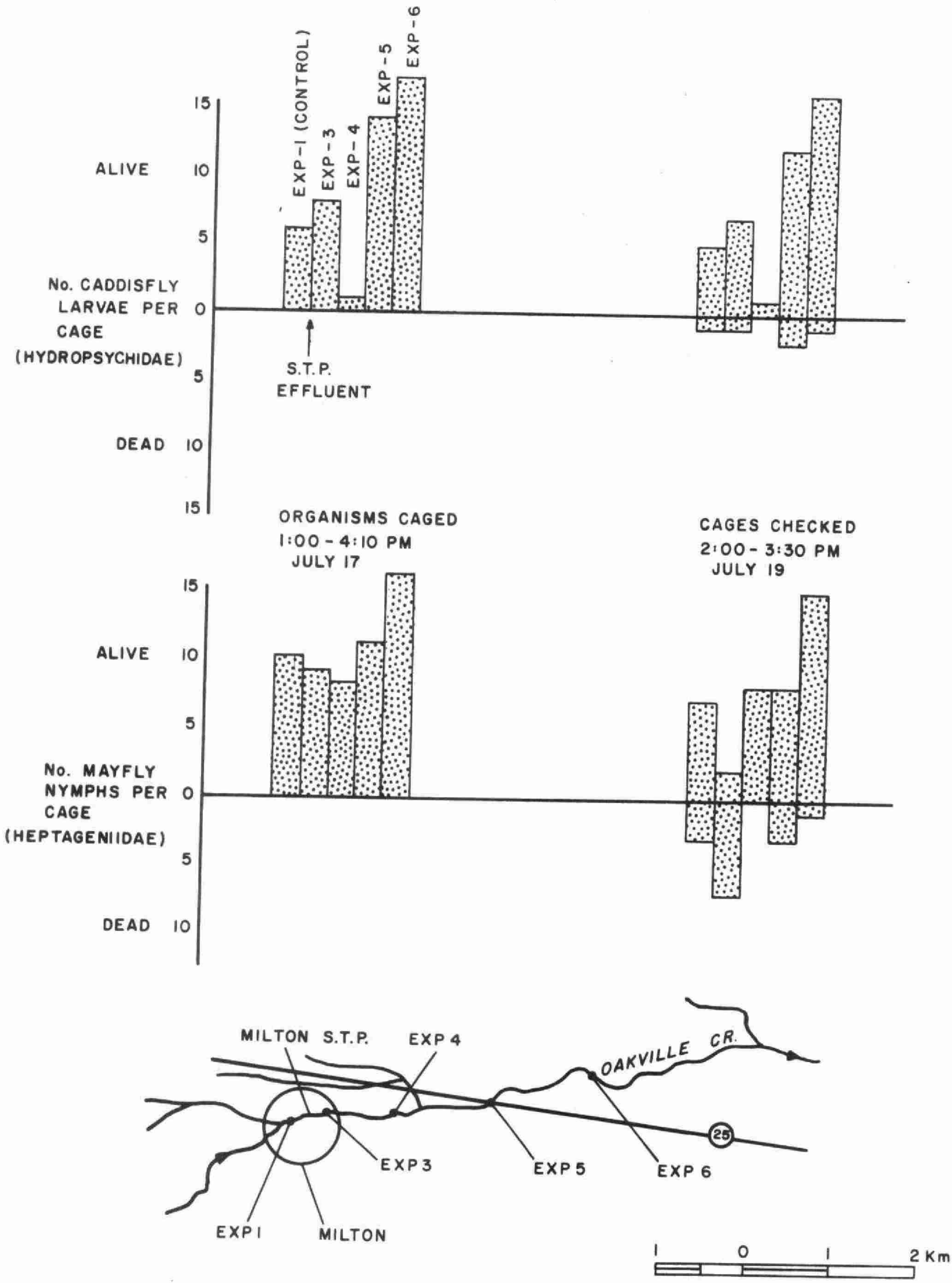


Figure 9: Results of Caging Experiments - Caddisflies and Mayflies

3.2.4 Mayflies

Nymphs of the family Heptageniidae were collected from EXP-6 and were caged on the afternoon of July 17. Numbers per cage varied from 8 to 16. Not unlike the caddisfly larvae, some of the specimens may have been injured in handling. Figure 9 illustrates that after two days exposure, mortality had occurred at all but one location. Much of this mortality probably resulted from handling the insects. However, the high mortality at EXP-3 would indicate that environmental conditions at this point were not suitable for the sensitive Heptageniidae nymphs. It is pertinent to recall that mayfly nymphs were not obtained in the artificial substrate sample obtained from Station B-17 which is located in the same general area as EXP-3.

3.2.5 Fish

On July 16, common shiners were collected from the stretch of creek between Milton and the Kelso Reservoir. Five shiners, approximately 10 to 12 centimeters long, were placed in each cage. The cages were checked two or three times each day until the end of the experiment on July 20 and any dead minnows were removed. On July 18, more common shiners were collected from the same collection area, and new cages were set up at EXP-1 and EXP-3.

All cages were placed in a part of the stream where the water flow was slow but readily detectable. The first cage at EXP-1 was initially subjected to a slightly faster flow of water, but the cage was moved to a slower-flowing area after three fish died during the first day.

Figure 10 illustrates the results from this fish-caging experiment. At the control station (EXP-1), three fish died during the first day and a forth one died on the third day (July 19). In the second cage which was planted at EXP-1 on July 18, one fish was found dead on the following morning, and a second specimen was found dead that afternoon.

Just downstream from the effluent at EXP-3, all five shiners were found dead, in the first cage, the morning after they were caged. In the second cage which was set up on July 18, only one specimen was alive on the morning of July 19, and all five fish had died by the afternoon.

At EXP-4, two fish died during the first day, and another died during the third day, leaving two fish at the end of the four-day experiment.

At the two downstream locations (EXP-5 and EXP-6), all of the minnows remained alive throughout the test period.

The death of all of the caged fish at EXP-3, and the partial kill at EXP-1 and EXP-4, is somewhat contradictory to the fish survey conducted by the Ministry of Natural Resources on August 8 and 9, 1973. The M.N.R.

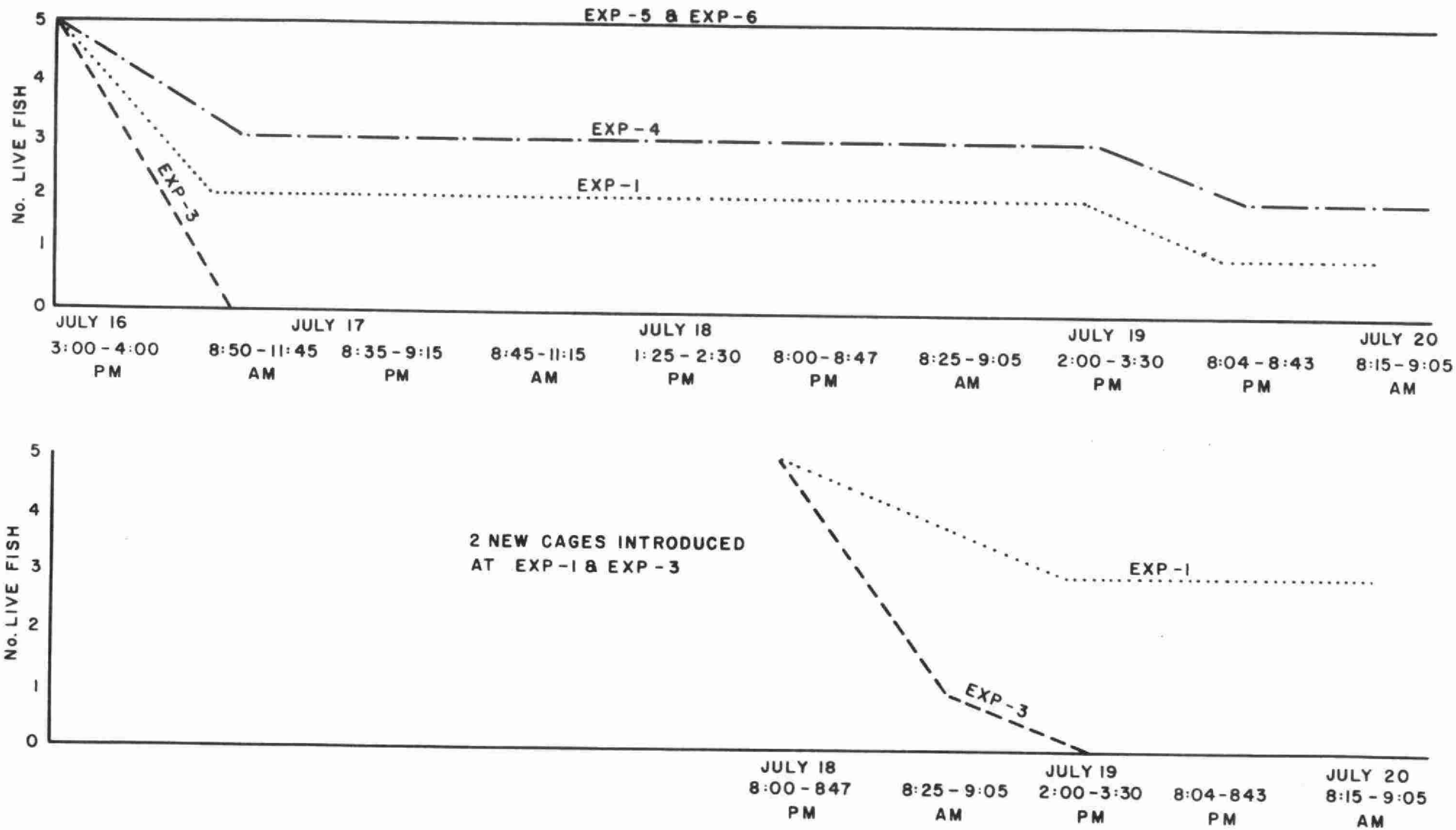


Figure 10: Results of the Caging Experiment - Common Shiners

found common shiners immediately below the sewage treatment plant outfall. However, because most of the stream width was sampled during the M.N.R. study, it is entirely possible that the shiners just downstream from the effluent were obtained from the side of the creek opposite the effluent plume. Another consideration in comparing the data from the two Ministries, is that the caging of fish results in unnatural stress which can weaken fish and make them much more susceptible to death. It would appear, however, that since no mortality occurred in the two downstream cages, (EXP-5 & EXP-6), the water quality in the Milton area, and particularly just downstream from the sewage treatment plant, is marginal for common shiners.

3.3 Fisheries

A study was conducted by the Ministry of Natural Resources in July 1973 to determine the effects of effluent from the Milton STP on the fish population. An analysis of species population and diversity was conducted for sampling stations immediately up and downstream from the sewage treatment plant outfall. Seventeen species were collected from the upstream stations and 13 species were collected from the downstream stations. The report concludes that although there are some differences in species and population, upstream and downstream differences were not statistically significant. Therefore, it could not be concluded that the STP had a major influence on population or species diversity immediately downstream from the sewage treatment plant.

The Ministry of Natural Resources' Sports Fisheries Branch provided a review of the fisheries of the main branch of Oakville Creek. They summarized their comments as follows:

"This branch (main branch Oakville Creek) provides many hours of recreation. It can be broken into four areas:

1. Area below Kelso Dam to Milton: an excellent trout area - all 3 species - but mainly rainbows and brooks. Provides challenge to both ardent and novice fishermen.

2. Milton Pond - a by-pass pond in town on the river. Stocked by the Ministry. Provides excellent return. This area brings much praise to the Ministry. Heavily utilized by pensioners and youngsters.

3. Area from Bronte Road to south limits of town: mainly spring sucker run which provides a great deal of excitement. Occasionaly browns and speckles caught in the area.

4. South of town limits: appears to be mainly browns. Several over 5 pounds caught this past season."

The Ministry's study found rock bass and smallmouth bass at all their stations downstream from Milton. The study also indicated there was a significant change in the fishery between stations upstream from the town development and stations within the town upstream of the STP. The quality of fish caught within the town limits and downstream from the town showed signs of deterioration as compared to those caught further upstream, as indicated by the presence of "black spot" infestations.

APPENDIX II

APPENDIX II

WATER QUALITY MODELLING OF OAKVILLE CREEK

A stream is a complex system composed of interacting physical, chemical and biological forces. The overall system or any of the sub-systems making up the whole, respond to changes in waste input, hydrodynamic and physical conditions. Some of these changes such as streamflow, are easily observed and are comparatively easy to predict. Other factors such as photosynthesis and respiration of dissolved oxygen due to aquatic plants are as significant but more difficult to measure.

A model of the several forces occurring in a watercourse is useful for solving immediate pollution problems and for assisting in long term planning of water use and development within a river basin. The purpose of the model is to reproduce mathematically, activities within the system and, once verified, to predict changes in water quality conditions for any combination of alterations to the various forcing functions.

In the Town of Milton, oxygen consuming wastes are discharged by the municipal sewage treatment plant (STP) to Oakville Creek. These materials significantly deplete dissolved oxygen for approximately two miles downstream from the STP. In order to predict the impact of the proposed future developments in Milton, a dissolved oxygen model was developed for the main branch of Oakville Creek from Milton to the confluence with the east branch.

1. DISSOLVED OXYGEN MODEL

A modified form of the Streeter-Phelps equations (O'Conner)* was used to model the dissolved oxygen concentrations in Oakville Creek for several waste loading conditions and stream flows. The model accounted for the effects of carbonaceous deoxygenation, nitrogenous deoxygenation, benthic deoxygenation, atmospheric reoxygenation, respiratory deoxygenation and pholosynthetic reoxygenation. The output of the model is the predicted dissolved oxygen concentrations for any chosen stream section and time of day. The model is presented below.

The DO-BOD Equations

$$D_{(x,t)} = D_o\, e^{-K_a (x/u)} + \frac{K_d L_o}{K_a - K_r}\left[e^{-K_r (x/u)} - e^{-K_a (x/u)}\right]$$

$$+ \frac{K_n L_o}{K_a - K_n}\left[e^{-K_n (x/u)} - e^{-K_a (x/u)}\right]$$

$$+ \frac{S}{K_a}\left[1 - e^{-K_a (x/u)}\right]$$

$$+ \frac{R}{K_a}\left[1-e^{-K_a(x/u)}\right]$$

$$- P_m\left[\frac{2p}{\pi K_a}\left(1-e^{-K_a(x/u)}\right)\right.$$

$$+ \sum_{n=1}^{\infty}\frac{b_n}{\sqrt{K_a^{2}+(2\pi n)^{2}}}\cos\left[2\pi n\left(t-t_s-\frac{P}{2}\right)-\tan^{-1}\left(\frac{2\pi n}{K_a}\right)\right]$$

$$\left.- e^{-K_a(x/u)}\sum_{n=1}^{\infty}\frac{b_n}{\sqrt{K_a^{2}+(2\pi n)^{2}}}\cos\left[2\pi n\left(t-t_s-\frac{P}{2}-\frac{x}{u}\right)-\tan^{-1}\left(\frac{2\pi n}{K_a}\right)\right]\right]$$

where:

$D_{(x,t)}$ = Dissolved oxygen deficit at a distance "x" (feet) from the source or point of reference and any time "t" (time of day).

u = Average stream velocity (feet/day)

D_o = Initial dissolved oxygen deficit at the point of reference (reference $(x/u = 0)$. The deficit is expressed in mg/l.

K_d = Coefficient of carbonaceous deoxygenation (day^{-1})

K_n = Coefficient of nitrogeneous deoxygenation (day^{-1})

K_r = Coefficient of BOD removal (day^{-1})

K_a = Coefficient of atmospheric reoxygenation (day^{-1})

L_o = Ultimate carbonaceous oxygen demand at point of reference or source $(s/u = 0)$. L_o is expressed in mg/1.

N_o = Nitrogeneous oxygen demand at point of reference or source $(x/u = 0)$. N_o is expressed in mg/1.

S = Oxygen demand of benthic deposits (mg/1)/day

R = Oxygen demand due to respiration of aquatic plants (mg/1)/day

P_m = The maximum rate of photosynthetic production of oxygen by aquatic plants (mg/1)/day

p = Fraction of day from sunrise to sunset

t = Time of day

t_s = Time of sunrise

$$b_n = \cos \frac{(n\pi p) \quad 4\pi/p}{\left(\frac{\pi}{P}\right)^2 - (2\pi n)^2}$$

The various coefficients used in the equation must be determined for the stream or water course in question. This calibration is based on the chemical data collected for several days at a number of locations. In addition data on the time of travel between chemical sampling stations, stream flow and velocity, and the intensity of sunlight must also be collected. The coefficients determined for Oakville Creek at the critical sections are listed in Table 3.

Table 3

MODEL CALIBRATION COEFFICIENTS

Section	K_2	K_r	K_d	P_m	R	K_n
4-8	5	.72	.72	40	17	3.3
8-9	6	.72	.72	56	35	0.88
9-10	10	.72	.72	35	28	1.2
10-11	13	.72	.72	58	44	0.83
11-13	6.8	.55	.55	15	15.5	0.55

The application of the model is assisted by the use of computer programs. Details of the model and its calibration and application are being prepared in report form by the Water Quality Branch.

* O'Connor, D.J., and DiToro, D.M., " Photosynthesis and Oxygen Balance in Streams", SED, ASCE, Vol. 96, No. S.A.2, Apr. 1970. p. 547.

2. APPLICATION OF THE MODEL

The dissolved oxygen model was used to predict the diurnal-nocturnal dissolved oxygen concentrations for four loading conditions:

1. The loading which occurred during the intensive survey (this was done to verify the model).

2. The loading from the present population with improved treatment and with the predicted low flow, without augmentation, of 4 cfs.

3. The loading from a population of 28,000 with sewage treatment and effluent quality as outlined in section 3.1 and with low flow augmentation of 13 cfs.

4. The loading from a population of 18,000 with sewage treatment and effluent quality as outlined in section 3.1 and with low flow augmentation of 13 cfs.

The input data for each of the loading conditions were the calibration coefficients, the average daily ultimate BOD load after mixing with the effluent, the average daily nitrogeneous load after mixing with the effluent, the time of travel, the dissolved oxygen concentration in the stream at 2 hour intervals and the saturation concentration for dissolved oxygen. The model was run for the first reach of the stream. Then the input data were updated for each consecutive reach and the dissolved oxygen prediction from the upstream reach was used as the input to the downstream reach.

For the application to the model upstream water quality was assumed to be similar to that found during the intensive study. Also the downstream biomass was assumed to remain unchanged for all the flow situations, which meant that the calibration coefficients would change in an inverse proportion to the change in stream flow, so that as flow increased the effects of photosynthesis and respiration on oxygen concentrations would decrease.

3. MODELLING RESULTS

Figure 11, 12, 13 compare the dissolved oxygen concentration predicted for each loading condition at the point downstream from the STP at distances of 0.9, 1.8 and 3.1 miles respectively.

For loading condition 1 the greatest D.O. fluctuation and lowest D.O. concentration occurs at Station 9. Water quality then improves downstream from Station 9 with minimum D.O. levels greater than 4 mg/l. These results agree favourably with the study data which should be the case since the study data were used to calibrate the model.

For loading condition 2 the D.O. levels are predicted to fall to zero during the night at Stations 8 and 9. Recovery begins to occur just upstream from Station 10. This situation occurs as a result of the large biomass in the stream relative to the predicted 7 day low flow of 4cfs. With the improved sewage treatment facilities critical water quality condition could occur in the stream under low flow conditions.

For loading condition 4 the lowest D.O. concentrations occur just upstream from Station 8 while the largest daily D.O. fluctuation occurs at Station 9. This situation is indicative of the lesser effect of the biomass as opposed to the first 2 loading condition. The carbonaceous and nitrogenous demands play a greater role in effecting the D.O. levels with low flow augmentation and phosphorous removal.

For loading condition 3 the lowest D.O. concentrations occur just upstream from Station 8 and again the largest daily D.O. fluctuation occurs at Station 9. The biomass again has a less important impact, while the carbonaceous and nitrogenous demands have reduced nocturnal D.O. concentrations to levels below 4 mg/l. Any additional loads would further reduce the D.O. concentration.

Results predicted by the model are summarized in the following table.

TABLE 4

WATER QUALITY PREDICTIONS OAKVILLE CREEK

Population	Flow cfs	STP BOD_5 mg/1	Minimum Dissolved Oxygen Predicted mg/1	Critical Section
8,000	10.9	13.3	2.7	Derry Road-Hwy#25
8,000	4	7.5	0.0	STP-Brittannia Road
28,000	13	7.5	3.4	STP-Derry Road
18,000	13	7.5	3.9	STP-Derry Road

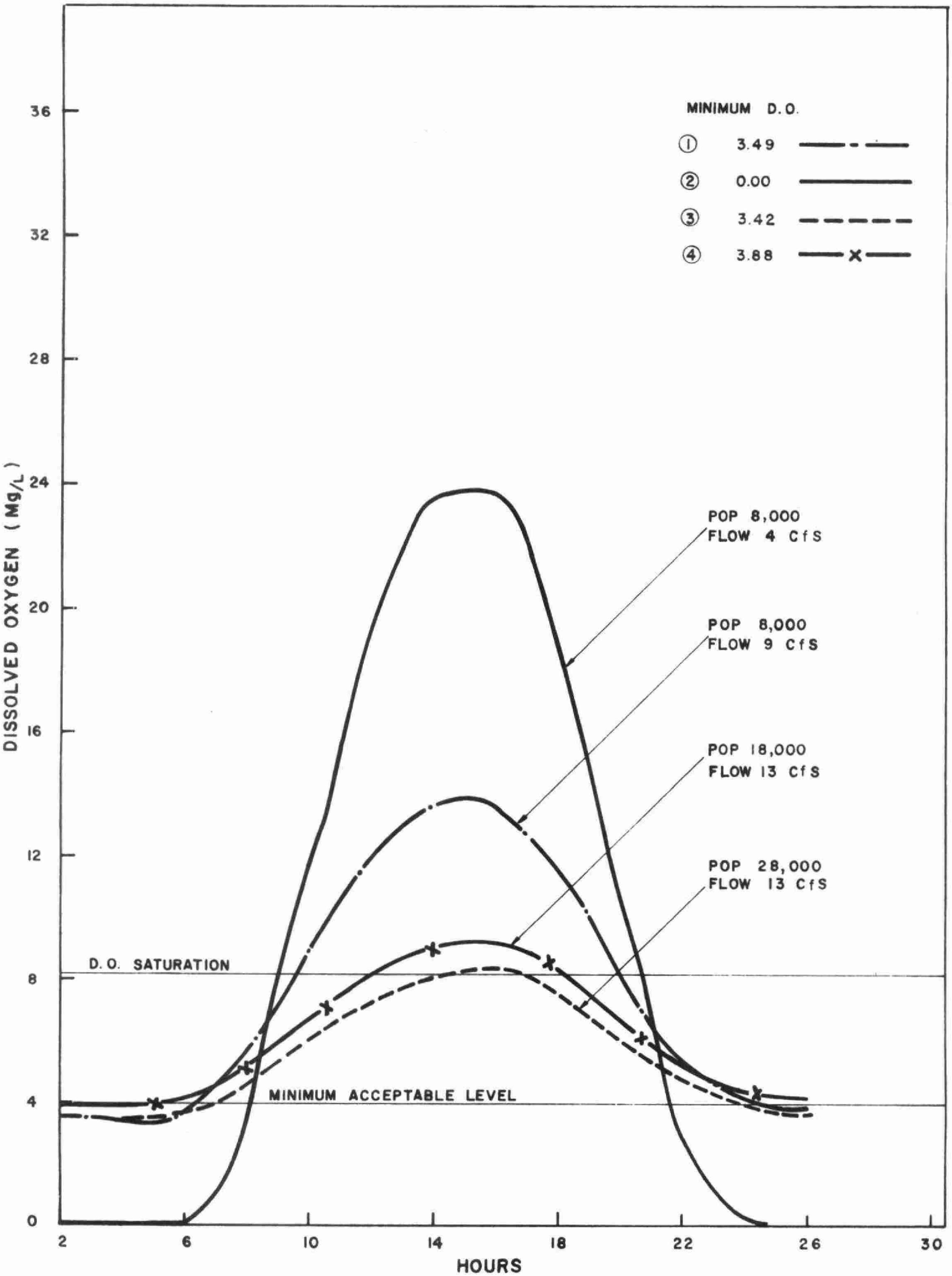


FIG. 11 STATION 8 OAKVILLE CREEK WATER QUALITY MODEL RESULTS DISSOLVED OXYGEN CONCENTRATION VERSUS TIME

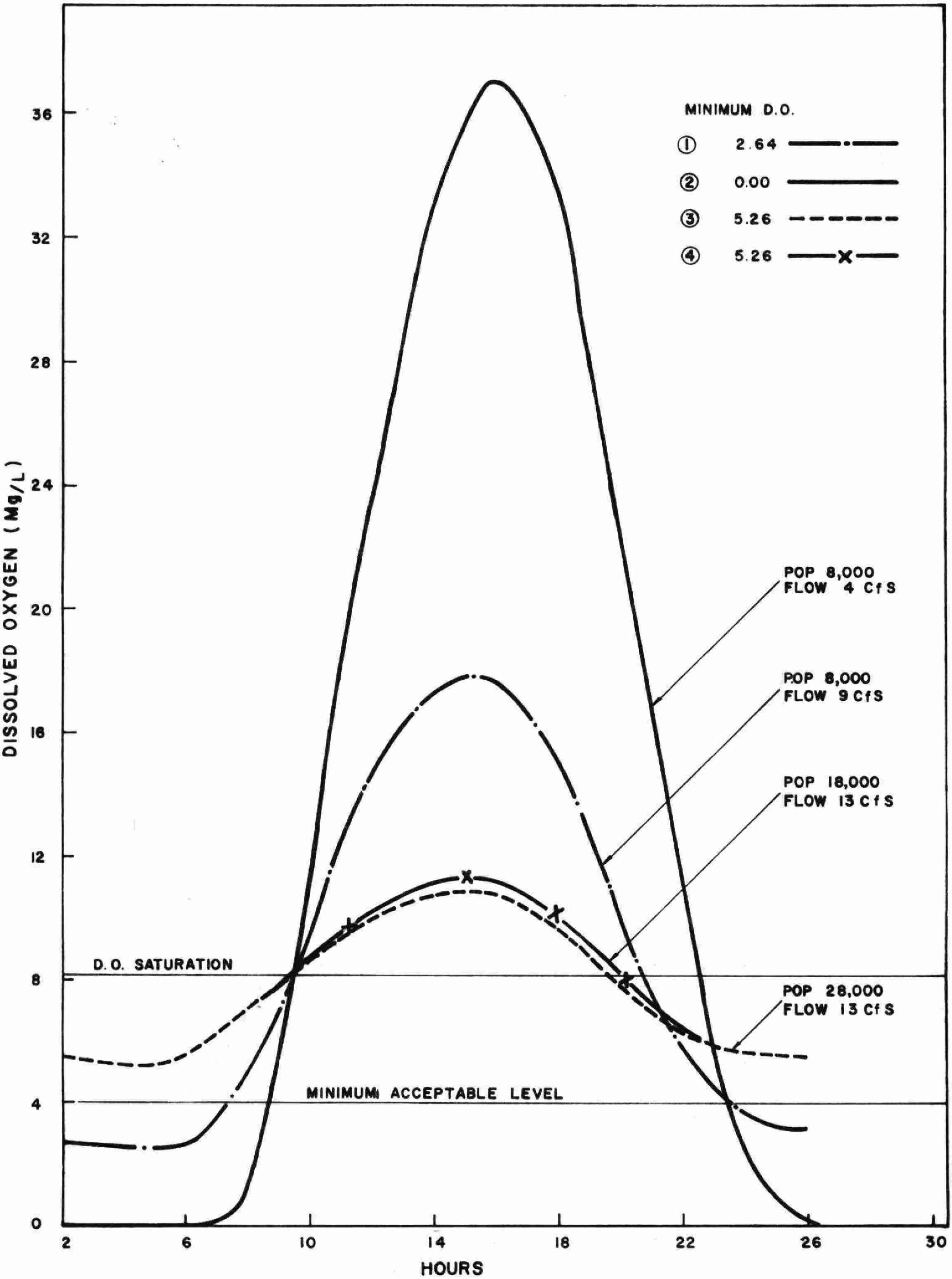


FIG. 12 STATION 9 OAKVILLE CREEK WATER QUALITY MODEL RESULTS DISSOLVED OXYGEN CONCENTRATION VERSUS TIME

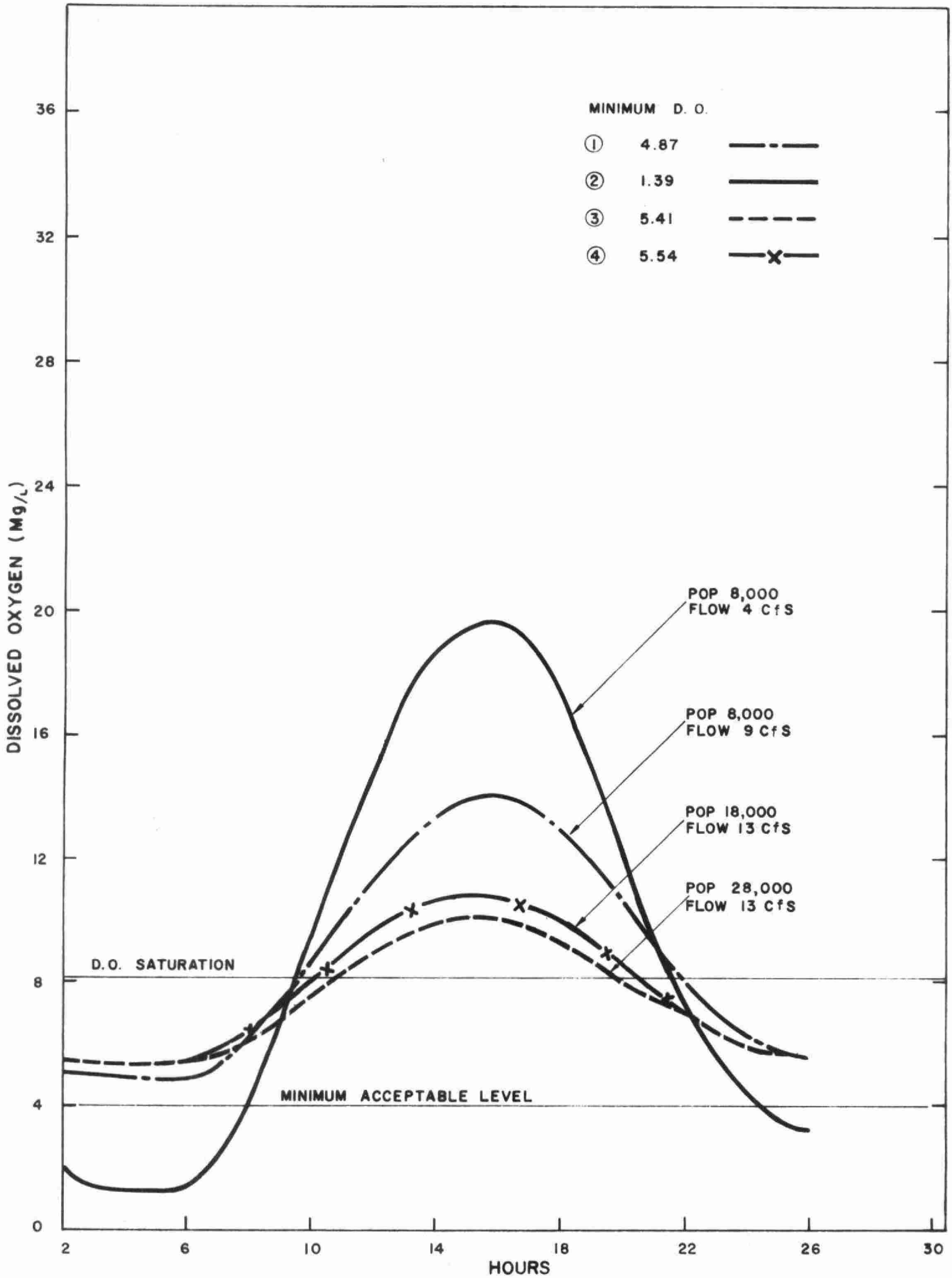


FIG. 13 STATION 10 OAKVILLE CREEK WATER QUALITY MODEL RESULTS DISSOLVED OXYGEN CONCENTRATION VERSUS TIME

4. DISCUSSION

The predicted dissolved oxygen levels for the various loading conditions are believed to be upper limits which could occur in the main branch of Oakville Creek. Most assumptions and estimates favour the best possible assimilative condition in the stream.

The assumption of no change in biomass was based on professional and technical experience of staff of the Water Quality Branch. For all the loading conditions it was felt that sufficient nutrients would be present downstream from the sewage treatment plant to at the least generate and maintain the biomass observed during the field study. An increase in biomass would result in a larger DO fluctuation and a reduction in the minimum DO concentrations. A decrease in biomass was felt to be unlikely under the four loading conditions.

In assuming no change in upstream water quality, most of the self-purification capacity of the stream is available for the assimilation of plant effluent. With increasing population it is extremely unlikely that the water quality upstream from the STP will improve. It is more likely that upstream water quality will degrade, especially if the storm sewer system is altered. An increase in upstream BOD_5 and nutrient load will result in a decrease in the minimum DO concentration for each of the loading conditions.

The loadings for the various conditions are average values expected to be achieved by the treatment systems. Any daily or hourly fluctuation about the average will result in greater loading to the stream and a consequent decrease in the minimum DO concentration. The assumed loading of 7.5 mg/1 BOD_5 is likely the average level which could be achieved with the conventional treatment methods outlined in Section 3.1.

The flow value of 13 cfs was based on 13 years of flow records, for which the available storage from Hilton Falls and Kelso reservoirs was tested and found to be satisfactory. Therefore, there is a better than a 92 percent chance that lower flows will not occur in any one year with low flow augmentation. However, based on the same data, it is likely that flows of as low as 13 cfs will occur for at least several weeks duration each year. This is significant in that there is no margin of safety involved in the flow values.

The total available flow of 13 cfs was applied to the model. There was no portion of the flow set aside to allow for fluctuations in loadings. The prediction then is based on the total available assimilation capacity of the creek.

It is likely then that the modelling procedure would tend to provide the highest dissolved oxygen levels that could be expected and that any errors or changes in assumptions would result in predictions of lower DO levels.
